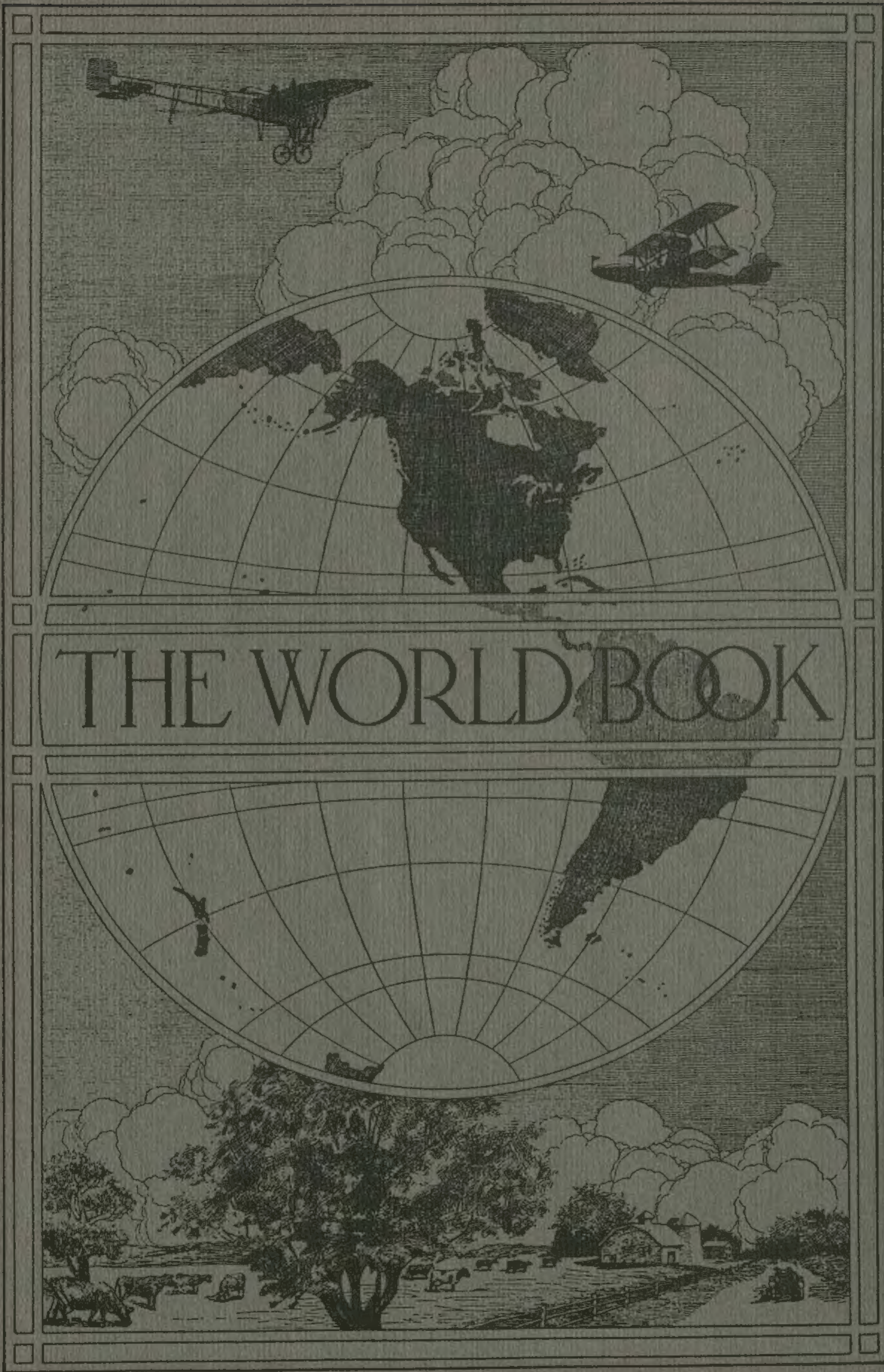
THE WORLD BOOK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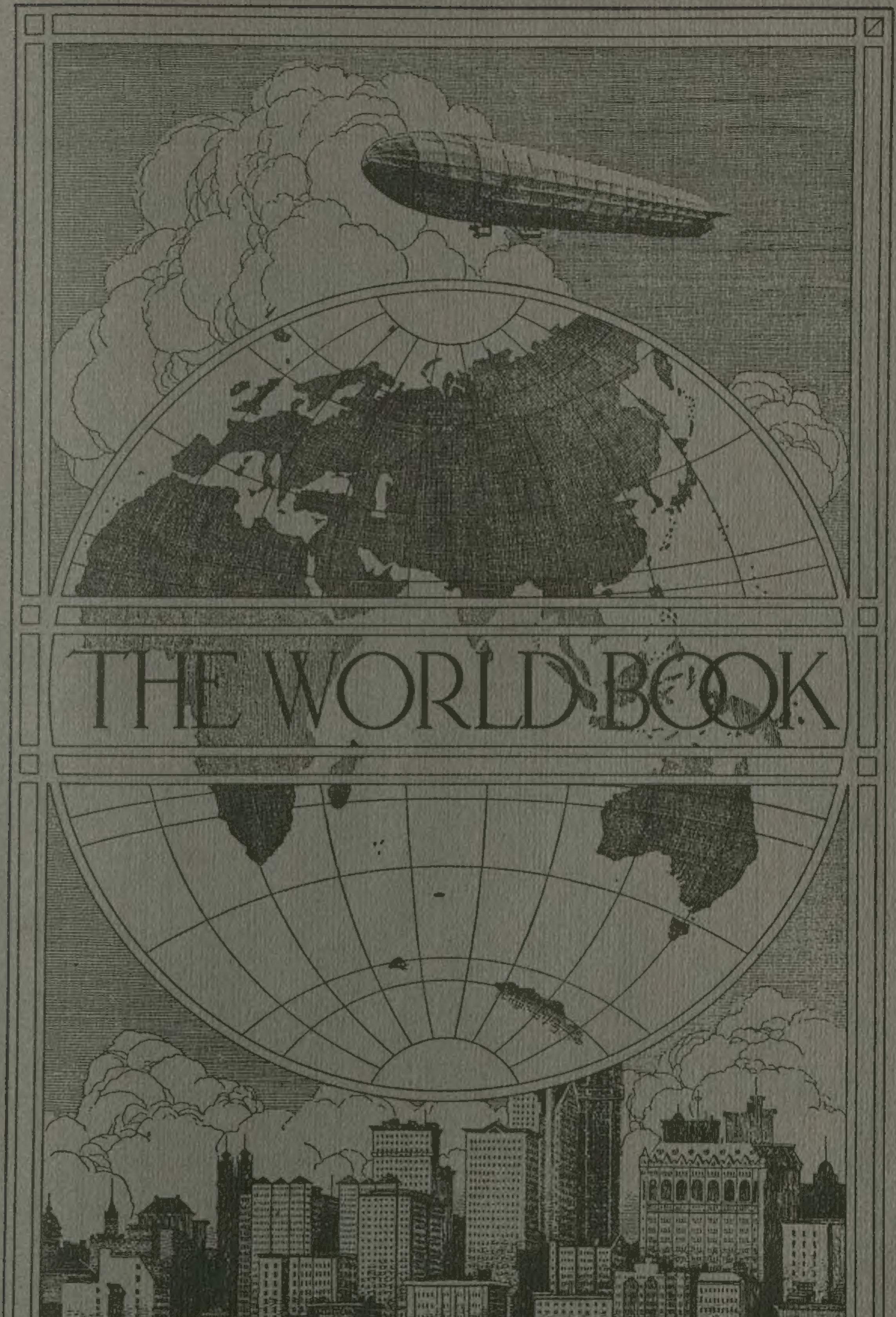
THE WORLD BOOK

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Qq

Q is the 17th letter of the English alphabet. It was also a letter in the alphabet used by the Semites, who once lived in Syria and Palestine. They named it *qoph* which may have been their word for *ape* or *monkey,* and they wrote it with a picture symbol that may represent a monkey. The Greeks later took the letter into their alphabet for a time, calling it *koppa.* The Romans adopted it from the Greeks, and gave it its present capital *Q* form. They also originated the usage of following *q* with *u.* See Alphabet.

Uses. *Q* or *q* is about the 25th most frequently used letter in books, newspapers, and other printed material in English. *Q* is used as an abbreviation for Quebec. In titles, *Q* may indicate *queen,* as in *Q.C.* for *Queen's Counsel,* and it can mean Quarter as in *Q* for *Quartermaster.*

The lower case *q* is used as an abbreviation for *quart, quarter, quarterly, query,* and *question.* A Latin phrase, *quod vide,* or *which see,* is represented by *q.v.* This abbreviation is used for cross-references in footnotes and other citations.

Pronunciation. *Q* followed by *u* in English has the sound of *kw* as a rule. People make this sound by narrowing and rounding their lips. The back of the tongue touches or is near the velum, or soft palate. The vocal cords do not vibrate. Final *que* as in *unique* has the sound of *k.* The combination *qu* also has the sound of *k* in such words as *liquor* and *croquet.* This combination has the sound of *k* or *kw* in French, of *kv* in German, and of *k* in Spanish. It is believed that the Romans pronounced it like *kw.*

Development of the letter Q

The ancient Egyptians, about 3000 B.C., drew a symbol of a monkey. The Semites adapted the symbol and named it *qoph,* their word for *ape* or *monkey.*

The Phoenicians used a symbol of a knotted cord to write the letter *qoph* about 1500 B.C.

The Greeks, about 800 B.C., developed a G-shaped letter called *koppa.* This letter was seldom used.

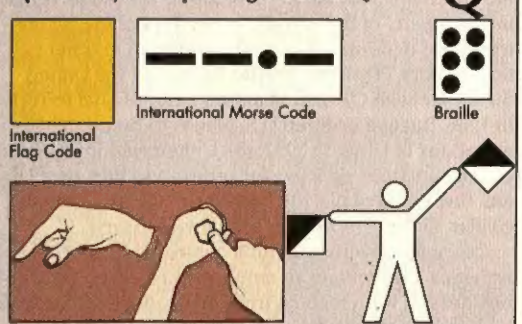
Q

The Romans gave the letter Q its present form about A.D. 114.

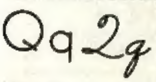
The small letter q appeared during the A.D. 500's. The vertical stroke followed the round part of the letter to distinguish it from the small p. By about 1500, the q had the form that is used today.

q A.D. 500 q 1500 q Today

Special ways of expressing the letter Q



Common forms of the letter Q



Handwritten letters vary from person to person. *Manuscript* (printed) letters, *left,* have simple curves and straight lines. Cursive letters, *right,* have flowing lines.

Qq *Qq*

Roman letters have small finishing strokes called *serifs* that extend from the main strokes. The type face shown above is Baskerville. The italic form appears on the right.

Qq *Qq*

Sans-serif letters are also called *gothic letters.* They have no serifs. The type face shown above is called Futura. The italic form of Futura appears on the right.

Computer letters have special shapes. Computers can "read" these letters either optically or by means of the magnetic ink with which the letters may be printed.

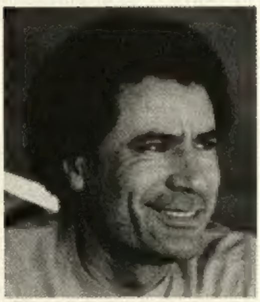
Q fever. See **Rickettsia.**

Qaboos bin Said (1940-), became sultan of Oman in 1970. During his reign, he has acted as prime minister, minister of defence, and minister of foreign affairs. Qaboos bin Said has tried to exercise a moderating influence on Arab affairs, and has always been favourable toward the United States.

Qaboos bin Said was born in Oman and educated in the United Kingdom, where he trained as a soldier. After his return to Oman, he was imprisoned in the royal palace by his father, Sultan Said bin Taimur (1910-1972), a strong opponent of modernization.

In July 1970, with British support, Qaboos overthrew his father. He began a cautious programme of social reform and economic development. He relied heavily on experts from the United Kingdom. British support also helped the Sultan prevent revolutionaries from setting up their own regime.

Qadhafi, Muammar Muhammad al- (1942-), took over the leadership of Libya's government in 1969. He came to power after he led a military overthrow of Libya's monarchy. He is a colonel and commander in chief of the Libyan armed forces. Other spellings of his name include Gadhafi, Kaddafi, and Qaddafi.



Muammar al-Qadhafi

Qadhafi is an outspoken radical leader with a strong belief in Arab unity. Qadhafi has tried unsuccessfully to form unions between Libya and other Arab states. He has also sought to spread his influence. Qadhafi has sent troops and military equipment into Chad, Uganda, and Western Sahara. He has given financial aid to revolutionaries and terrorists in many parts of the world. The leaders of many countries have denounced him for interfering in other nations' affairs. President Ronald Reagan of the United States accused Qadhafi of aiding international terrorists. In 1986, Reagan ordered U.S. planes to bomb military installations in Libya. In 1992, the United Nations (UN) imposed sanctions on Libya for refusing to turn over Libyans suspected of placing bombs on two international civilian flights. For details, see **Libya** (History).

Qadhafi's government took control of many economic activities. Committees of employees replaced heads of businesses. With income from oil production, Qadhafi built many schools, houses, and hospitals, and his government provides free social services for all citizens. However, Libya needs more skilled workers to continue its economic development.

Qadhafi was born near the town of Surt, Libya. He attended the Libyan Military Academy in Benghazi and the Royal Military Academy at Sandhurst, England.

Qandahar, also spelled *Kandahar* (pop. 191,345), is the second largest city of Afghanistan. Qandahar lies in southern Afghanistan (see **Afghanistan** [map]).

The old section of Qandahar includes many ancient buildings and bazaars. The city also has modern sections. An airport lies southeast of Qandahar.

Qandahar serves as the centre of an important trade route between India, Iran, Pakistan, and Kabul. It also processes and exports fruit grown in the area.

Qandahar existed as early as 1000 B.C. It became the capital of an Afghan empire in A.D. 1747. Ahmad Shah Durrani, the founder of the empire, built the modern city of Qandahar in 1761. Kabul replaced Qandahar as the capital in 1776.

Qantas is Australia's only international airline. Its initials stand for *Queensland and Northern Territory Aerial Services.* This company was founded by Sir Fergus McMaster, Sir Hudson Fysh, and P. J. McGinness in 1920. The company opened the first air service in eastern Australia, between Charleville and Cloncurry in Queensland, in November 1922. In 1934, Qantas and Imperial Airways founded Qantas Empire Airways Ltd. to operate the Brisbane-Singapore section of the Britain-Australia route. The name *Qantas Empire Airways Ltd.* was changed in 1967 to *Qantas Airways Ltd.* The airline now provides extensive round-the-world services.

See also **Airline; Fysh, Sir Hudson.**

Qatar is a small Arab country in southwestern Asia. It occupies a peninsula that juts from eastern Arabia into the Persian Gulf.

For Qatar's total population, see the *Facts in brief* table with this article. Most people live in or near Doha, the capital (see **Doha**). Over two-thirds of the people were born in other countries. The native born are called Qataris. Until the 1940's, most tended camel herds,

Qatar

fished, or dived for pearls for a living. Today, most Qataris work in cities or oil fields.

Qatar's economy depends largely on oil and petroleum products. Since the 1950's, the government has earned much income from oil exports and used it to develop Qatar. Qatar ranks among the richest nations in terms of average income per person. The government provides free education. It also provides free health care and housing for the poor.

Qatar became a protectorate of the United Kingdom in 1916. It gained full independence in 1971.

Government. Qatar is an *emirate.* An *emir* (prince) rules the country. The emir is a member of the al-Thani family, which has ruled Qatar since the mid-1800's. He appoints an 18-member Council of Ministers. An advisory council, made up of 30 elected deputies and 3 deputies appointed by the Council of Ministers, also aids the emir in the running of the country. The government allows no political parties.

People. Oil was discovered in Qatar in 1939. By the 1950's, the oil industry was providing more jobs than had ever been available in Qatar before. As a result, thousands of people moved to Qatar from other Arab countries. In 1990, Qatar had about 20 times as many people as it did in 1950. Arabs make up about 95 per cent of the population. Arabic is the official language, but many business executives and government officials use English when they deal with people from other countries. Islam is the state religion.

Most of Qatar's people live in or near Doha in modern houses or flats. Some Qataris wear Western clothing, but most prefer traditional Arab garments.

The government requires children from the age of 6 to 16 to go to school. The number of schools in Qatar rose from 1 in 1952 to about 160 by the early 1990's. About half the people can read and write. Special schools help raise the literacy rate by teaching adults to read and write.

Land and climate. Qatar covers about 11,000 square kilometres, most of which is stony desert. Barren salt flats cover southern Qatar.

Summer temperatures sometimes rise above 49 °C, but the winter is cooler. Qatar seldom gets more than 10 centimetres of rain a year.

Qatar has little natural water. It therefore has to distil most of its drinking water, which comes from the sea. The people grew few crops until the late 1950's, when the government dug wells and made crop growth possible.

Facts in brief about Qatar

Capital: Doha.
Official language: Arabic.
Official name: The State of Qatar.
Area: 11,437 km². *Greatest distances*—north-south, 185 km; east-west, 89 km. *Coastline*—378 km.
Population: *Estimated 1996 population*—500,000; density, 38 people per km²; distribution, 90 per cent urban, 10 per cent rural. *1986 census*—369,079. *Estimated 2001 population*—551,000.
Chief products: Petroleum and petroleum products.
Flag: The left third is white with a vertical series of points on the right side. The right two-thirds is maroon. See Flag (picture: Flags of Asia and the Pacific).
Money: *Currency unit*—Qatar riyal. One riyal = 100 dirhams.

Doha is the capital and largest city of Qatar. Examples of the city's traditional Islamic architecture are shown above. But much of Doha has a modern appearance.

Economy. Oil ranks as Qatar's most important product and chief export. The exportation of petroleum and petroleum products provides 95 per cent of the nation's income. Qatar is a member of the Organization of Petroleum Exporting Countries (OPEC). The nation's government encourages the development of manufacturing, farming, and fishing so Qatar will not have to depend entirely on its oil for income. The government owns and operates the petroleum wells and refineries; flour mills; a fishing fleet; and plants that produce fertilizers, cement, steel, petrochemicals, and plastics. Fertilizers are Qatar's second most important export.

Qatar produces enough vegetables for its people but must import much meat and other food, and most manufactured goods. The government helps farmers to cultivate grain and fruit by distributing free seeds and insecticides.

Doha has a port and a modern airport. Roads link Doha to the rest of Qatar and to neighbouring Saudi Arabia and the United Arab Emirates. The government owns and operates a radio and television station.

History. People have lived in what is now Qatar for thousands of years. Before oil was discovered, they made a living by raising camels, fishing, or pearl diving.

The people of Qatar had no strong government until the late 1700's, when the Wahhabis, an Islamic sect from Saudi Arabia, took control of the country. During the mid-1800's, *sheiks* (Arab chiefs) of the al-Thani family became the leaders of Qatar's tribes. The Ottoman Turks extended their control to Qatar during the late 1800's. In 1916, Qatar became a United Kingdom protectorate.

Exploration for oil in Qatar began in 1930. The government granted a 75-year drilling right to the foreign-owned Qatar Petroleum Company in 1935. The company first discovered oil in 1939 in western Qatar. But World War II began that year and delayed any oil exportation until 1949. Since the 1950's, oil has made Qatar a rapidly developing country.

Qatar became an independent nation in 1971. That same year, Qatar became a member of the Arab League and the United Nations. In 1972, Khalifa bin Hamad al-Thani, the deputy ruler, became emir after peacefully overthrowing his cousin, Emir Ahmad bin Ali al-Thani. In the mid-1970's, the government took ownership of Qatar's petroleum industry. In 1981, Qatar and other states of eastern Arabia formed the Gulf Cooperation Council to work together in such matters as defence and economic projects.

Qin dynasty, also spelled *Ch'in,* was a Chinese *dynasty* (family of rulers) that governed from 221 B.C. to 206 B.C. The dynasty began after Shi Huangdi, ruler of the state of Qin in northwestern China, conquered rival northern and central states. He later extended his rule to southeastern China. The dynasty had complete control over the areas it ruled. Earlier, local Chinese chiefs had much control over their regions.

Shi Huangdi ruled his empire with an iron hand. He made former local rulers move to his huge new capital at Xianyang and appointed local administrators who were responsible to him. He banned most books in an attempt to silence critics, to promote obedience, and to blot out knowledge about the past. He ordered large numbers of labourers to complete the Great Wall of China to keep invaders out. But Shi Huangdi gave his country a lasting ideal—national unity. The name China came from the name of his dynasty.

Shi Huangdi died in 210 B.C., and his son proved to be a weak ruler. Rebellions began in 209 B.C., and the Qin dynasty soon collapsed. The Han dynasty then gained control of China.

See also **Great Wall of China; Shi Huangdi.**

Qu Yuan (340?-278? B.C.) was a great patriotic poet of ancient China. His poetry became widely known throughout the world in the mid-1900's.

Qu Yuan was born in the state of Chu, where his family were aristocrats. While still in his twenties, he was appointed to an important position by King Huai the ruler of Chu. Qu Yuan advocated reforming policies including appointing wise and able people and exercising rule by law. Rival officials plotted against him and he was sent into exile. After the capital city of Chu was captured by the army of Qin, he felt it was impossible to save his country. Later, he committed suicide by jumping into the Milo river.

During his lifetime, Qu Yuan created highly expressive poetry of a new type. The collection of poems called *The Elegies of Chu* reflected the best of Chu's folk songs and legends. The poems of Qu Yuan include "Li Sao" (Encountering Sorrows), "Heavenly Questions," "Nine Songs," and "Nine Chapters." "Li Sao" is the most imposing, long lyric poem in ancient Chinese literature. Its exquisite language and its richness of imagination make it a masterpiece of romanticism.

Quadratic equation. See **Algebra** (Quadratic equations in one unknown).

Quadrilateral is the name given to a plane figure with four straight sides—that is, a four-sided *polygon.* A quadrilateral whose opposite sides are parallel is a *parallelogram.* The opposite sides and opposite angles of any parallelogram are equal. If the angles of a parallelogram are right angles, the figure is a *rectangle.* If all four sides are equal, the figure is a *rhombus.* A parallelogram that has four equal sides and four right angles is a *square.* The area, A, of any parallelogram with base b and altitude h is given in the formula $A=bh$. The altitude is the perpendicular distance between the base and the side opposite it.

A *trapezoid* is a quadrilateral with one set of parallel sides of unequal length. The trapezoid is *isosceles* if the nonparallel sides are equal.

See also **Rectangle; Rhombus; Square.**

Quadrillion is a thousand million millions in the United States and France. This is the meaning for quadrillion used in this encyclopedia. One quadrillion is written with 15 zeros: 1,000,000,000,000,000. In Australia and Great Britain, a quadrillion has, in some cases, 24 zeros. See also **Decimal system** (The decimal system and number words).

Quadroon. See **Mulatto.**

Quadruplets. See **Multiple birth.**

Quahog. See **Clam.**

Quail is a type of small bird that belongs to the same family as pheasants and partridges, grouse, turkeys, and guineafowl. They live in open grassland, scrub or swampy areas on every continent except Antarctica. There are about 45 species of quail. They are often hunted for sport or food.

Most adult quail are 20 to 30 centimetres long. Males are shades of brown or grey and may have striking patterns of reddish-brown, blue, white, or black feathers. Most females are patterned in shades of brown, tan, or grey. These colours help protect quail from enemies by making the birds hard to see when they sit quietly at the base of clumps of grass.

During autumn and winter, quail live together in groups called *coveys.* Depending on the kind of quail, a covey may have 10 or fewer birds or as many as 100 or more. The covey helps protect its members from predators such as foxes and birds of prey. When such an enemy or a hunter approaches a covey, the quail squawk loudly and fly away in all directions. The covey

The common quail breeds in Europe or Asia. It feeds on seeds and insects and lives in a group called a covey.

breaks up in spring, and males and females form pairs for the nesting season.

Most quail can only fly short distances. They fly low with a rapid whirring of the wings. The *common quail* is unusual as it migrates long distances, from Africa to Europe, or from India to central Asia to breed. It looks like a tiny partridge, about 18 centimetres long. The related *stubble quail* of Australia is found only in southern Australia and Tasmania.

New World quails tend to be larger, sturdier birds, boldly marked with black, white, and grey, and have strong bills. Some species, such as the Gambel's quail of the southwestern United States, have a head plume that curves forward, and is larger in the male. The bobwhite quail is one of the best known North American species. It is 24 centimetres long and lives in scrub areas mainly in the eastern, central and southern United States. Some species of Central American quail live in trees.

Quail lay on average 12 eggs in a shallow nest, hidden among grasses on the ground. The young usually stay with their parents for their first summer.

Scientific classification. Quail belong to the pheasant family, Phasianidae. The common Eurasian quail is *Coturnix coturnix,* the stubble quail is *C pectoralis,* Gambel's quail is *Lophortyx gambelii* and the bobwhite quail is *Colinus virginianus.*

See also **Partridge; Grouse; Bird** (pictures).

Quakers is the popular name for members of the Religious Society of Friends. Quakerism developed in England in the 1600's. Today, a majority of its followers live in the United States. England and Kenya also have large Quaker populations. Smaller Quaker groups exist in most other parts of the world.

Quakers have been known throughout their history for their humanitarian activities. They reject war and stress peace education. They have been pioneers in removing barriers to racial equality and have been among the leaders in prison reform and in the humane treatment of mental patients. Quakers have always been concerned with education, and the high quality of their many schools and colleges has been widely recognized.

History. George Fox of England founded Quakerism. His spiritual experience led him to witness what he called the *Inner Light* of Christ that dwells in the hearts of ordinary people. Those who followed that Inner Light were considered truly spiritual and following God's will. Fox began preaching in 1647 and attracted a variety of religious seekers during that period of social and political revolution in England. The word *Quaker* was originally meant as an insult to Fox, who told an English judge to "tremble at the Word of the Lord." The judge called Fox a "quaker."

From the beginning, the Quakers emphasized inward spiritual experiences rather than specific creeds. The early Quakers, or Friends, developed radically fresh forms of worship and business proceedings. These forms were based on a trust in the Holy Spirit and faith that ordinary laypeople were able to receive the Holy Spirit.

In 1682, a Quaker, William Penn, founded the colony of Pennsylvania as a haven for the continually persecuted English Quakers who wished to emigrate to the New World. Penn gave the colony a constitution that was a model for safeguarding the religious liberties of its citizens.

Worship. Quakers regard all life as sacramental and observe no special sacraments. Business and worship are conducted in monthly, quarterly, and yearly meetings. Originally, Quakers worshipped by gathering together in whatever place was available for periods of group silence. During the silence, the faithful attentively waited for the Lord to exercise His power upon their lives; to lay on them "the burden of the world's suffering" and their responsibility to respond to it. Anyone who felt he or she had been given a message during the silence could speak at the meeting.

Quaker business meetings are guided by a *clerk.* After a period of silent waiting, the clerk states a particular problem and listens to the members' suggestions. Then, without being bound to anyone's specific suggestion, the clerk presents for group consideration a *minute* that seeks to resolve the problem. No votes are taken to reach a solution, but the process continues until even opposing minorities are at least satisfied that their position has had a hearing and that it has been considered.

The loose organizational structure of the Religious Society of Friends has always given a great deal of liberty to its regional yearly meetings. This liberty has resulted in a variety of worship and spiritual patterns in different parts of America, Europe, and other parts of the world. The Friends World Committee for Consultation has its offices in Birmingham, England. It is a communications centre for many regional yearly meetings in the world.

Related articles in *World Book* include:

Fox, George	Penn, William
Marriage (Wedding ceremonies and customs)	Prison (Early prison reform)
	Whittier, John Greenleaf

Quandong is a small, slim tree that grows in the dry parts of Australia. It reaches 6 to 9 metres. Quandongs have narrow, bright-green leaves and small white flowers. They bear large, round fruits that ripen from a light-green colour through bluish-purple to rich red. The ripened fruits consist of an outer succulent part and a very hard "stone" that contains an edible nut, known as dong, or quandong, nuts. The fleshy part can be made into good preserves. The stone is brown, wrinkled, and pitted, and is used for beads and as counters. The timber is hard and durable, though small in diameter, and is used in cabinet work. The Aborigines used quandong wood for tanning skins.

Scientific classification. Quandong belongs to the family Santalaceae. It is *Eucarya acuminatum.*

Quango is an organization set up by the British government to carry out work on many projects. The term *quango* was invented in the 1970's and stands for *Quasi-Autonomous Nongovernment Organization.* Quangos are funded by the government, but the government does not administer their work. To this extent, they are *quasi-autonomous* (almost self-governing).

Quangos operate mainly as commissions. Their fields of activity have ranged widely, including such diverse activities as advertising employment opportunities to the public and advising the government on ancient monuments.

Over many years, the number of quangos in the United Kingdom grew steadily. By the mid-1970's, there were more than 3,000 of them. Typical quangos in-

cluded the Manpower Services Commission, the National Enterprise Board, and the New Town Development Corporation. More obscure quangos were also set up, covering topics such as the Detergents and Allied Products: Voluntary Notification Scheme Scrutiny Group.

In 1979, the UK Conservative government decided to review the need for and purposes of quangos. Afterwards, it abolished many quangos and deprived others of state funding.

Quanta. See **Photon; Quantum mechanics.**

Quantock Hills are a ridge of hills in western Somerset, England. The hills extend southwards for about 14 kilometres from the Bristol Channel towards Taunton. The wooded ridge is a noted staghunting region. The highest point of the Quantock Hills is Will's Neck, 385 metres high.

Quantum electrodynamics is a theory concerning the interaction of electrons and electromagnetic radiation. It deals with the properties of electrons, positrons, and photons; with these particles' mutual interactions; and with their interactions with magnetic and electrical fields. Electrons have negative electrical charges. Positrons are electrons with a positive electrical charge. Photons are packets of radiation that can be considered as particles of light.

Photons are emitted by, and form, electrons and positrons under certain conditions. These interactions produce changes in charge and other particle properties. Quantum electrodynamics, also called QED, helps physicists predict and calculate these changes with high precision.

The fundamental contributions to the development of QED were made in the 1940's by physicists Richard P. Feynman and Julian S. Schwinger of the United States and Sin-itiro Tomonaga of Japan (see **Feynman, Richard P.**).

Quantum mechanics is a field of physics that describes the structure of the atom and the motion of atomic particles. It also explains how atoms absorb and give off energy as light, and it clarifies the nature of light.

Quantum mechanics goes beyond the limits of classical physics, which is based on the laws formulated by the English scientist Sir Isaac Newton. It ranks as one of the major scientific achievements of the 1900's. Quantum mechanics, in addition to its theoretical importance, has contributed greatly to the development of such practical devices as lasers and transistors. It also has enabled scientists to gain a better understanding of chemical bonds and chemical reactions.

Understanding quantum mechanics. In an atom, tiny particles of negative electrical charge called *electrons* move in orbits around a nucleus of positive charge. Quantum mechanics shows that the electrons can move only in certain orbits. Each orbit, called a *quantized* orbit, has a particular value of energy. When an electron is in a given orbit, it exists at a specific energy level and does not release or absorb energy. An electron remains in this normal state as long as its atom is not disturbed. But if outside forces act on the atom, the electron can change to another quantized orbit.

When an electron jumps from an orbit of higher energy to one of lower energy, it gives off energy as light. This light is released in the form of a tiny bundle of energy called a *quantum* or *photon*. The energy of a photon corresponds to the difference in energy of the two orbits between which the jump occurs. An electron also can absorb a photon and jump from an orbit of lower energy to one of higher energy. In this way, quantum mechanics explains the process through which the atom gives off and absorbs light photons.

Scientists once believed light was a wave emitted as a continuous flow. But we now know that light has characteristics of both particles (photons) and waves. A photon has energy which is proportional to the *frequency* (number of vibrations per second) of the waves.

Pure light forms a single spectrum line that represents a particular frequency or colour. The atoms of a chemical element give off waves of a wide range of frequencies to produce many different lines. This series of lines makes up the chemical element's spectrum, which differs from that of any other element. The frequencies of an element's spectrum lines can be calculated by using quantum mechanics.

Quantum mechanics shows that electrons and other atomic particles of matter are also associated with waves. These waves, called *matter waves,* have a specific wavelength. The wavelength is inversely proportional to the frequency of the waves and to the particle's *momentum*. The particle's momentum is calculated by multiplying the mass of the particle by its velocity.

Matter waves provide an explanation for the arrangement of electrons in separate orbits. When an electron is undisturbed, its wave fits around the atom's nucleus at a distance such that the wave can join smoothly onto itself. The electrons of a single atom have waves of different wavelengths. These electrons form orbits at varying distances from the nucleus.

Another fundamental idea of quantum mechanics is the *uncertainty principle.* According to this principle, the position and velocity of a particle cannot simultaneously be measured with exactness. The principle is valid because a particle has certain wave properties. In addition, the method used to determine a particle's position and velocity does not allow for unlimited precision. For example, in order to make such measurements, physicists must shoot photons at the particle to "see" it. But these photons collide with the particle and thus disturb its position and velocity. As a result, physicists can only measure these characteristics of the particle with some precision, but not exactly.

History. In 1900, the German physicist Max Planck introduced the idea of quanta to explain the spectrum of light emitted by certain heated objects. In 1905, the German-born physicist Albert Einstein broadened Planck's idea to explain a phenomenon called the *photoelectric effect.* In doing so, Einstein firmly established that light consists of particles of energy that have wave properties. Niels Bohr, a Danish physicist, proposed the theory of the atom's electron structure in 1913. He also showed how atoms radiate light. Scientists call Bohr's work *quantum theory* to distinguish it from the broader system of quantum mechanics.

Louis de Broglie, a French physicist, introduced the idea of matter waves in 1924. The physicists Erwin Schrödinger of Austria and Werner Heisenberg of Germany independently developed forms of quantum me-

chanics in the mid-1920's. Since that year, these forms have been unified into a system and applied to several scientific fields, including chemistry, molecular biology, and solid-state physics.

Related articles in *World Book* include:

Atom	Jordan, Ernst P.
Bohr, Niels	Light (Quantum mechanics)
Born, Max	Photon
De Broglie, Louis Victor	Physics (Quantum theory)
Dirac, Paul A. M.	Planck, Max K. E. L.
Einstein, Albert	Schrödinger, Erwin
Heisenberg, Werner	Solid-state physics

Quantum theory. See **Quantum mechanics.**

Quarantine is the isolation of certain people, places, or animals that may carry danger of infection. The period of quarantine depends on the amount of time needed to protect against a certain disease.

The practice of formal quarantine dates back to Venice in the 1300's. The city authorities recognized that ships from the eastern Mediterranean were responsible for the introduction of plague. At first, ships were isolated for 30 days *(trentina),* but this was later extended to 40 days—*quarantina.* Venice opened its first quarantine station on an island near the city in 1423. This system was soon adopted by other countries and it became the model for international quarantine control.

Today, with better understanding of communicable diseases, quarantine of human beings is rarely necessary. However, international quarantine may still be exercised at ports, airports, and border crossings if a confirmed case of serious infectious disease, such as cholera or bubonic plague, is found on board a ship, aircraft, or train. If such disease is present, a ship must stay in harbour flying a yellow flag.

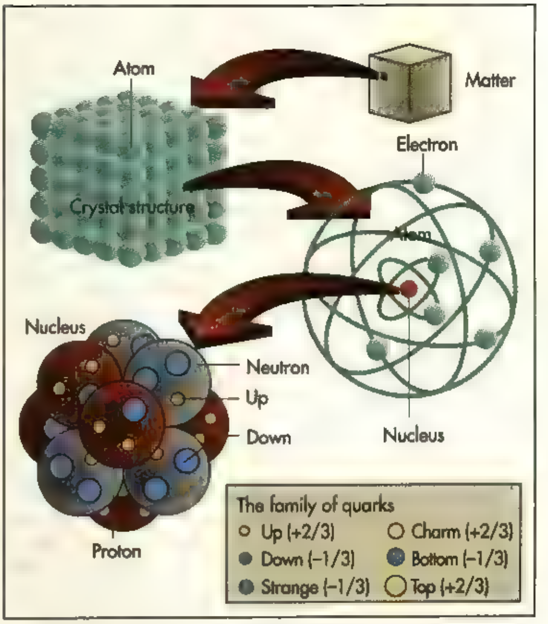
Animals are also often subject to quarantine. In the United Kingdom this usually lasts six months and is designed to keep out rabies (see **Rabies**). Both Australia and New Zealand have strict regulations to prevent animal and plant diseases. No cattle or sheep may be imported into these countries. Other animals must be accompanied by health certificates, and may be isolated in quarantine stations for long periods. Any imports of raw animal products, such as hair or hides, are specially treated to destroy any possible infection.

Related articles in *World Book* include:

Bill of health	Fumigation	Sanitation
Epidemic	Insect (Insect control)	

Quark is a particle that physicists believe to be the basic subunit of neutrons and protons. Every neutron and proton consists of three quarks. Quarks do not seem to exist singly, but always in combination with other quarks. They are bound together by a force transmitted by particles called *gluons.* Each quark carries an electric charge that is either minus one-third or plus two-thirds the charge of a proton. Quarks make up one of the three major families of elementary particles. The other families are bosons and leptons.

Scientists believe that there are six types of quarks. Ordinary matter contains two types, designated *up* (or *u*) and *down* (or *d*). But physicists have created other quarks with a device called a *particle accelerator.* An accelerator causes subatomic particles to collide violently with one another, producing quarks that are considerably heavier than u's and d's. These quarks are unstable and break down into u's and d's in less than a billionth of a second. The heavier quarks include those with such fanciful names as "charm," "strange," "top," and "bottom."



Quarks are a family of elementary particles. The diagram above shows matter magnified to reveal part of a crystal with tightly packed atoms. Each atom has electrons orbiting a nucleus. Up quarks and down quarks combine to form the protons and neutrons that make up the nucleus of ordinary matter. The other types of quarks are produced in nuclear explosions and atom-smashing experiments.

The quark theory was first proposed in 1964 by two American physicists, Murray Gell-Mann and George Zweig. They believed that *hadrons* (neutrons, protons, and other kinds of subatomic particles), which scientists had believed were the most basic bits of matter, consisted of even simpler particles. Direct evidence of quarks appeared in 1971, when studies using accelerators indicated the presence in protons and neutrons of objects at least 50 times as small as protons. Quarks are now known to be at least 1,000 times as small as protons.

See also **Gluon; Hadron; Psi particle; Proton; Upsilon particle.**

Quarrying is a method of taking large solid blocks or broken masses of stone from the earth and preparing them for construction projects. A *quarry* is a large pit in the earth from which the stone is taken. Kinds of stone taken from quarries include basalt, granite, limestone, marble, sandstone, and slate.

Some quarries are dug into the sides of mountains. Most are open at the surface. A quarry may be over 30 metres deep and many times that in width. Stone is quarried by (1) the plug and feather method, (2) the explosive method, or (3) channelling by machinery.

Plug and feather method. Rocks can be split along smooth lines by exerting constantly increased pressure evenly on all parts of the rock's surface. With this pressure, workers can break the rock into any size and shape. Evenly cut blocks are called *dimension stone.*

The principal tools are a *plug* (wedge), which is flat on

its two opposite surfaces, and two pieces of steel, called *feathers,* which are rounded on one side and flat on the other. The first step is to drill holes about 19 millimetres in diameter into the rock in a straight line. A wedge is placed between two feathers and all three are inserted in a hole. When all the holes are filled, workers drive the wedges and feathers downward to split the rock. The rock broken off is turned over to other workers. They split the rock into smaller pieces by the plug and feather method, or with hand tools.

Explosive method is generally used to break off huge masses of rock from their place in the earth. Strong explosives are best if crushed stone is desired. Crushed stone is widely used in paving roads and making concrete. When larger, more regular stones are desired, a milder explosive is used. In both cases, holes are drilled deep into the solid mass. The explosive is put into the holes and set off by slow-burning fuses or electric firing. Sometimes hundreds of tons of stone are forced out of the earth in a few huge pieces.

Channelling by machinery. Most large quarries use a channelling machine to make the first cut into a solid bed of rock. It looks like a small engine with long chisels on the sides. The machine moves along a track on top of the rock and forces the chisels downward. Gradually, the chisels cut the rock to any depth from 0.3 to 3 metres. The rock is broken off below by blasting or by the plug and feather method.

Quart is a unit of capacity or volume for both dry and liquid substances. It is equal to two pints, or one-fourth of a gallon. The imperial quart is sometimes used for dry and liquid measurement in such countries as the United Kingdom, Canada, Australia, New Zealand, and South Africa. It is equal to 1.13652 litres.

In the United States, one liquid quart is equal to 0.94635 litre, and one dry quart is equal to 1.10122 litres.

See also **Weights and measures.**

Quarter is a United States coin worth 25 cents, or a *quarter* (fourth) of a dollar. The government issued the first quarters in 1796. The Washington quarter was first minted in 1932, the 200th anniversary of George Washington's birth. Washington's head appears on one side, and an eagle is on the other side. Quarters of several other designs were used before the Washington quarter. In 1975 and 1976, the government issued special bicentennial quarters. The coins featured Washington on one side and a colonial drummer on the other.

Until 1965, quarters contained 90 per cent silver and 10 per cent copper. Because of a shortage of silver, the Coinage Act of 1965 eliminated silver from the coin. Since then, it has consisted of a layer of copper between layers of a copper-nickel mixture.

The Washington quarter pictures George Washington on one side. An eagle appears on the coin's reverse side.

Quarter days are four days that each mark the beginning of one quarter of the year. They are traditionally regarded as settling days for certain debts that are payable in quarterly instalments, such as electricity, gas, and telephone accounts.

In England, Wales, and Ireland, the quarter days are four religious festival days that fall about three months apart. They are *Lady Day* (The Feast of the Annunciation, March 25), *Midsummer Day* (The Feast of St. John the Baptist, June 24), *Michaelmas Day* (The Feast of St. Michael and All Angels, September 29), and *Christmas Day* (The Feast of the Nativity, December 25).

In Scotland, the quarter days are known as *term days.* They are *Candlemas* (the Feast of the Purification, February 2), *Whitsunday* (Pentecost, always on May 15 in Scotland), *Lammas* (Long Mass, or the Feast of First Fruits, August 1), and *Martinmas* (The Feast of St. Martin, November 11).

Quartz is a common mineral that occurs in many types of rocks. Pure quartz is colourless and transparent. It is composed of silicon dioxide and has the chemical formula SiO_2. Quartz has many important uses in science and industry.

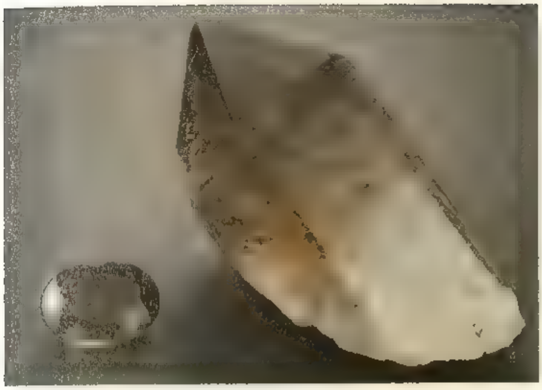
Quartz can be found in several forms and in all three major kinds of rocks—*igneous, metamorphic,* and *sedimentary* (see **Rock**). Except for feldspar, it is the most common rock-forming material in the earth's continental crust. Quartz is also one of the hardest minerals. Beryl, spinel, topaz, corundum, and diamond are among the few harder minerals. Erosion does not wear away quartz as rapidly as it wears away most other rock materials.

Types. There are many varieties of quartz. Geologists often divide them into two general groups, *coarse crystalline* and *cryptocrystalline.*

Coarse crystalline forms of quartz include six-sided prismlike crystals and massive, granular clumps in which the individual grains of quartz can be seen. *Rock crystal* is a coarse crystalline quartz that occurs as colourless, transparent crystals. Some coloured varieties of coarse crystalline quartz crystals, such as *amethyst* and *citrine,* also called *false topaz,* are cut into gemstones. Granular forms of coarse crystalline quartz include *quartz sandstone* and *quartz sand. Rose quartz* and *milky quartz* are coloured granular forms.

The colour of a type of coarse crystalline quartz results from small amounts of aluminium, calcium, iron, lithium, magnesium, sodium, or other elements in its crystal structure. For example, the bluish-violet colour of amethyst is caused by the presence of iron and manganese. Colouring may also result from changes or defects in the crystal structure of quartz. The smoky appearance of *cairngorm,* also called *smoky quartz,* is produced by such alterations. The decay of a radioactive element, such as uranium or thorium, in quartz releases high-energy radiation that alters the crystal structure. Because of this change, light rays cannot penetrate the crystal, and a smoky colour results.

Cryptocrystalline forms of quartz have individual grains of quartz that can be seen only with a microscope. These forms include *chalcedony, chert, flint,* and *jasper.* Petrified wood consists of chalcedony that has



Smoky quartz gets its smoky colour from changes in the crystal structure of colourless quartz. The mineral appears as a six-sided crystal on the right and as a cut gem on the left.

replaced the original wood fibre. *Carnelian* and *agate* are varieties of chalcedony used as gems.

Properties and uses. Quartz has an important property called the *piezoelectric effect* (see **Piezoelectricity**). When a *plate* (slice) from a quartz crystal is mechanically compressed, it develops a positive charge on one side and a negative charge on the other. This phenomenon is piezoelectric generation of voltage across the crystal. It enables an electric current or signal to pass through the crystal. Quartz crystals are used in the wave transmitters of radios, TV sets, and most radars. In such transmitters, the electric signal generated is amplified and changed into a radio wave of a certain frequency.

The piezoelectric property of quartz also provides the basis for the operation of quartz watches and clocks. Voltage applied to a quartz crystal plate causes the plate to expand and contract, producing vibrations at a uniform rate. The size of the plate determines the number of vibrations per second. The vibrations are then translated into seconds, minutes, and hours. See **Watch** (Electronic watches).

Quartz does not expand much when heated, or crack when cooled rapidly. These properties make quartz an important material in making glass containers that can withstand extremely high temperatures.

Rock crystal is used in making lenses for some microscopes and telescopes. Large crystals of quartz are also used in the manufacture of certain other optical devices. Most quartz crystals used for industrial purposes are produced synthetically because of the limited supply of suitable natural crystals. Quartz sandstone is a common building material. Quartz sand is used in making sandpaper and grindstones.

Related articles in *World Book* include:

Agate	Chalcedony	Jasper
Amethyst	Flint	Mineral (picture)
Carnelian	Hardness	Onyx

Quartzite is a rock composed chiefly of the mineral quartz. The quartz occurs both as individual grains and as the cementing material that holds the grains together. Quartzite ranks as one of the hardest rocks.

Quartzite is a common type of metamorphic rock (see **Metamorphic rock**). Quartzite is formed when heat and pressure cause quartz sandstone to *recrystallize*—that is, form new mineral grains. In the process, the quartz grains become so firmly bonded that any breaks that occur in quartzite go through the grains rather than pass around them.

See also **Earth** (picture: The earth's three kinds of rocks).

Quasar is an extremely luminous object at a great distance from our galaxy. Because such objects look much like stars in photographs, they became known as *quasi-stellar* (starlike) *objects,* but the term is usually shortened to *quasars.* Most quasars may be about the size of the solar system. But they can be a trillion times brighter than the sun. Many astronomers believe quasars are the most distant objects yet detected in the universe. Some may be as far as 16 billion light-years from the earth (see **Light-year**).

Astronomers determine how distant a quasar is by measuring its *red shift.* Red shift is a shift in the wavelength of light given off by an astronomical object toward the longer, or red, wavelengths of the object's spectrum. It indicates an object is moving away from the earth. The more distant the object is, the larger is its red shift. All quasars have large red shifts, which is why they are assumed to be so far away. See **Red shift.**

Quasars give off enormous amounts of energy in the form of visible light, ultraviolet light, infrared rays, X rays, and in some cases, radio waves. Light from quasars takes so long to reach the earth that the light seen today was actually given off by the quasars billions of years ago. For this reason, the study of quasars can provide astronomers with information about early stages of the universe.

Radio waves emitted by quasars were first detected by astronomers in Cambridge, England, in the 1950's. Quasars were first identified by optical observations in 1963 by a group of astronomers at the Palomar Observatory, near San Diego, California, U.S.A. Since then, some 5,000 quasars have been discovered. Astronomers are not yet sure how quasars generate their vast quantities of radiation. Some believe quasars are powered by a giant black hole that produces energy by swallowing clouds of gas from a nearby galaxy (see **Black hole**).

See also **Radio telescope.**

Quasimodo, Salvatore (1901-1968), an Italian poet, won the 1959 Nobel Prize for literature. Until about 1942, Quasimodo belonged to the *hermetic* school, a group of poets who wrote in a difficult, personal style that seemed sealed off from everyday life. Largely because of World War II (1939-1945), Quasimodo turned to a style that dealt with the events of his time. Beginning with *Day after Day* (1947), his poetry became an accurate reflection of the grief and destruction that the war had brought to humanity.

Quasimodo was born in Modica, near Syracuse, Sicily. In 1918, he moved to northern Italy. His first poems were published in literary magazines in Florence and later as a collection called *Waters and Lands* (1930). He also wrote many essays on literature, and translated the work of such writers as E. E. Cummings, Molière, Sappho, and William Shakespeare.

Quaternary Period. See **Earth** (table).

Quayle, Dan (1947-), served as vice president of the United States from 1989 to 1993, during the term of President George Bush. Before becoming vice presi-

dent, Quayle represented Indiana in the United States Senate from 1981 to 1989. He had previously served two terms in the U.S. House of Representatives.

Dan Quayle

Quayle, whose full name is James Danforth Quayle, was born on Feb. 4, 1947, in Indianapolis, Indiana. He graduated from DePauw University in Greencastle, Indiana, in 1969 with a degree in political science. In 1974, Quayle received a law degree from Indiana University in Indianapolis. Quayle was elected to the United States House of Representatives in 1976 and in 1978 from a district in northeastern Indiana. In the House of Representatives, he had a consistently conservative voting record.

In 1980, Quayle won election to the U.S. Senate. He was reelected in 1986. He served on the Senate's Budget, Armed Services, and Labor and Human Resources committees.

In August 1988, the Republican National Convention nominated Quayle for vice president at Bush's request. The selection sparked immediate controversy. Much of the controversy centred on charges that Quayle used his family's influence to get into the Indiana National Guard in 1969, thereby avoiding being conscripted into the Regular Army and possibly seeing combat in the Vietnam War (1957-1975). However, Bush stood by his choice.

In 1992, Bush and Quayle again became Republican nominees. But they were defeated by the Democratic candidates, Governor Bill Clinton of Arkansas and Senator Al Gore of Tennessee.

Queanbeyan (pop. 24,943) is a city on the Queanbeyan River in New South Wales, Australia. It is situated on the border of the Australian Capital Territory, about 325 kilometres by rail from Sydney.

Farmers in the Queanbeyan district raise beef cattle or sheep, or combine wool production with wheat growing. Secondary industries in the city include woodworking, brick and concrete manufacturing, light engineering, and the manufacture of clothing.

The city is closely associated with the capital city Canberra, and it grew rapidly as Canberra developed.

Quebec (pop. 6,895,963) is the largest province of Canada. About 80 per cent of the population have French ancestors. These people largely follow the customs and traditions of France. In 1974 the National Assembly adopted French as Quebec's official language, making it the language of business and government, and promoting French-language instruction in schools.

Service industries such as education and health care employ a third of the province's workers. There is also a large tourist trade.

See also **Gulf of Saint Lawrence; Hudson Bay; Montreal; Quebec** (city).

Quebec is the capital city of the province of Quebec and the oldest city in Canada. The French explorer Samuel de Champlain founded Quebec in 1608. Quebec ranks as an important Canadian port and tourist centre. Among the cities in the province, only Montreal and Laval have more people. Quebec lies at the point where the St. Charles River flows into the St. Lawrence River. Nearby, the St. Lawrence narrows to about 0.8 kilometre. The city's name comes from an Algonquian Indian word meaning *the river narrows here.*

Quebec is the only walled city in North America. But most of the present-day city lies outside the walls. Quebec's many churches, old stone houses, and crooked cobblestone streets give it the charm of an old European city. The Château Frontenac, a castlelike hotel with

Quebec, the capital of the province of Quebec, lies on the St. Lawrence River. The Château Frontenac, *left,* a hotel, helps give Quebec the charm of an old European city.

towers, red brick walls, and a steep copper roof, rises dramatically from the Quebec skyline.

The city has been called the *Cradle of New France* because it served as the main base of early French explorers and missionaries in North America. Quebec also has the nickname *Gibraltar of America* because of the Citadel, a huge fort on the cliffs above the St. Lawrence River. In 1759, British troops defeated the French on the Plains of Abraham, west of the Citadel. In 1763, the Treaty of Paris gave Canada to Great Britain.

A majority of the people who live in Quebec have French ancestors. Sir Wilfrid Laurier, the nation's first French-Canadian prime minister, said that "Quebec is to French Canadians what Mecca is to Arabs—the most sacred city."

The city. Quebec covers 93 square kilometres. The city has an old section that makes up about 10 square kilometres to the north of the Citadel. The old section, in turn, has two parts, Upper Town and Lower Town. The Quebec metropolitan area spreads over 2,818 square kilometres.

The Citadel overlooks the city from a height of 106 metres. It stands on the highest point of Cap Diamant. The British completed the Citadel in 1832.

The people. About 98 per cent of Quebec's people were born in Canada. About 95 per cent of the population have French ancestors, and most of the rest have British ancestry. Roman Catholics make up by far the largest religious group, more than 95 per cent of the people. Most Quebecers speak French, so signs and other public notices appear in that language.

Major problems in Quebec include unemployment and deterioration of old neighbourhoods in Lower Town. Lack of adequate housing is also a problem.

The economy. Quebec lies about 290 kilometres from Montreal, a major centre of Canadian industry. The city's nearness to Montreal has limited its industrial development, but more than 500 manufacturing companies operate in the Quebec area. They employ almost 17,000 workers and produce about 800 million U.S. dollars worth of goods annually. Most of the industrial sites are along the St. Charles River. Shipbuilding, papermaking, and the manufacture of cement rank as the leading industries. Tourism also plays an important role in the city's economy.

The port of Quebec handles more than 14.5 million metric tons of goods yearly. Its chief exports include grain, ore, and pulp and paper.

History. Algonquian and Iroquoian Indians once farmed and hunted in the area that is now Quebec. The French explorer Jacques Cartier spent the winter of 1535 near the Iroquoian village of Stadacona. Samuel de Champlain established a permanent settlement there on July 3, 1608, and named it Quebec.

In September 1759, General James Wolfe's British troops defeated French forces under the Marquis de Montcalm on the Plains of Abraham. The British captured Quebec five days later (see **Quebec, Battle of**). The Treaty of Paris, which ended the Seven Years' War in 1763, gave Canada to the British.

See also **Quebec** (province); **Champlain, Samuel de; Seven Years' War.**

Quebec, Battle of, settled the fate of the French empire in America. France's defeat at Quebec in 1759 led to the Treaty of Paris of 1763 that gave Canada and all French territory east of the Mississippi River to Great Britain.

About 2 million British colonists were living along the eastern seaboard when the Seven Years' War began in 1756 (see **Seven Years' War**). About 60,000 French lived in America, mostly in Canada. The British wanted to expand westward, but a chain of French posts blocked their move. Without a formal declaration of war, the British attacked French settlements in Ohio. The Marquis de Montcalm took command of French troops in 1756 but after some successful advances, in 1758 his army of about 5,000 regulars had to fall back on Quebec. The city stood on heights dominating the Saint Lawrence River, and seemed impregnable to attack. French cannon covered all ship movements.

For three months, the British urged the French in the fortified city to surrender.

British troops under the command of General James Wolfe landed on the Île d'Orléans, 8 kilometres east of Quebec, in June, 1759.

Their attack on Quebec began during the cloudy, calm night of Sept. 12-13, 1759. The tide bore British flatboats to the Anse au Foulon, at the foot of the cliffs leading to the Plains of Abraham. The men climbed silently to the Plains west of the city and surprised a larger enemy post. By dawn, 5,000 British regulars had scaled the cliffs and were ranged for battle on the Plains. Montcalm quickly moved up 4,000 militiamen and Indians to meet the enemy. They arrived about 10 that morning.

The French fired too quickly at the British, who advanced in closed ranks and held their fire. When the French were near at hand, the British fired, reloaded, fired again, and then charged with bayonet and sword. The French retreated in disorder. Wolfe was wounded mortally in the first shots. Montcalm, who had been trying to rally his men, was wounded about the same time. His men brought him back to Quebec, where he died a few hours later. In 15 minutes, the fate of the French empire in America had been settled.

The Treaty of Paris of 1763 reduced all French possessions in North America to two small islands off the coast of Newfoundland, St.-Pierre and Miquelon.

Quebracho is a type of South American tree that grows mainly in Argentina and Paraguay. The wood of quebracho trees contains 20 to 30 per cent tannin. Workers extract the tannin and export it to the United States for use in tanning leather. The name *quebracho* means *axe-breaker* in Spanish. Quebracho trees have hard, tough wood called *quebracho colorado wood.* The name *quebracho* is also used for other South American trees that have hard wood.

Scientific classification. Quebracho trees belong to the cashew family, Anacardiaceae. They make up the genus *Schinopsis.*

Quechua. See **Inca** (Communication and learning); **Peru** (Languages).

Queen, the insect. See **Ant** (Life in an ant colony); **Bee; Insect** (Family life); **Termite.**

Queen is the title of a woman who rules a kingdom in her own right, or who is the wife of a king. If she rules in her own right, she is called a *queen regnant.* She has the same powers that a king would have, depending on the constitution of the country she rules.

If the queen is the wife of the king, she is called a *queen consort.* The mother of the ruling monarch is the *queen mother,* and the widow of a king is a *queen dowager.* Each of the queens has her own household. But none exercises any official power in the government.

Kings or queens of the United Kingdom and other constitutional monarchies have few powers of government. But they can refuse the advice of the prime minister, and they can influence public opinion.

For names of queens, see names of individuals; for example, **Elizabeth II.** See also **Coronation; King; Prince consort; Royal Family of the United Kingdom.**

Queen, Ellery, was the pen name of two American cousins, Frederic Dannay (1905-1982) and Manfred B. Lee (1905-1971), who became successful detective-story writers. Ellery Queen is also the name of their chief fictional character. They also published under the name of Barnaby Ross.

Dannay and Lee were both born in New York City. They became full-time writers soon after they won a detective-story contest in 1928. The story became their first Ellery Queen novel, *The Roman Hat Mystery* (1929). The early Ellery Queen novels especially are excellent examples of the cleverly plotted mystery puzzle. In 1941, Dannay and Lee founded *Ellery Queen's Mystery Magazine,* which publishes original detective fiction and reprints detective fiction classics. As editor and anthologist, Ellery Queen made a major contribution to the popularity of mystery fiction in the United States.

Queen Anne's Bounty was a fund that Queen Anne of Great Britain (now the United Kingdom) established in 1704 to supplement the incomes of the poorer clergy. The fund was financed by certain payments to the Crown from the Church of England. These payments were known as *first fruits and tenths.* In 1936, an act of Parliament abolished the payments, and Queen Anne's Bounty received government stock in compensation. Queen Anne's Bounty became part of the capital of the Church Commissioners in 1947.

Originally, the first fruits and tenths were payments made to the pope. Henry VIII directed that they should be made to the Crown when he made himself head of the Church of England.

Queen Anne's lace. See **Wild carrot.**

Queen Elizabeth 2. See **Ship** (pictures).

Queen Mary, a ship. See **Ship** (Ocean liners).

Queen's Awards for Export and Technology are awarded to companies in the United Kingdom for outstanding achievement in increasing exports or in *technological innovation* (using new methods or producing new products). The awards can be won by any branch of industry, including agriculture. Holders of either award—for export achievement or for technological achievement—receive a copy of the award's emblem cast in steel and mounted in a transparent block. The holders are entitled to display the emblem on their printed stationery and on their products if they wish. For export awards, the emblem has a letter *E* in its centre. For technology awards, it has a letter *T.*

The Queen's Award for Export gives winners the right to display this emblem on their products. The Technology award has a *T* instead of an *E.*

Companies apply for the awards themselves. The names of award winners are announced each year on the Queen's Birthday. The Queen's Award to Industry was first made in 1966. In 1976, it was renamed the Queen's Awards for Export and Technology.

Queen's birthday is celebrated in the United Kingdom on a Saturday early in June, not on the Queen's actual birthday, April 21. The celebration comes close to the anniversary of her coronation, June 2, and usually has better weather for trooping the colour than late April (see **Trooping the colour**). Honours are announced on this day (see **Honours and awards**).

The Queen's Birthday is also celebrated as a public holiday in New Zealand and in all the states of Australia. The holiday is celebrated on the first or second Monday in June, according to proclamation, in New Zealand and five of the states. In Western Australia, it is celebrated in October. In Australia, the custom of honouring the sovereign's birthday dates from 1788, when Governor Phillip declared a holiday to honour the birthday of King George III, June 4.

Queen's counsel. See **United Kingdom, Legal systems of the** (The legal profession).

Queen's evidence. In the United Kingdom, when a person accused of a crime volunteers, and is permitted, to give evidence against others involved in the crime, he or she is said to have turned *Queen's evidence.* A person who turns Queen's evidence is generally not prosecuted for the crime. In a trial, a judge must warn a jury against using such evidence without an unbiased supporting statement. In which case, an appeal court could quash a verdict of guilty.

In the Republic of Ireland, a criminal who gives evidence against confederates in a crime is known as an *approver.*

Queensberry, Marquess of (1844-1900), John Sholto Douglas, a Scottish sportsman, sponsored the modern boxing code that came to bear his name (see **Queensberry Rules.** The rules were actually written by John Graham Chambers of the Amateur Athletic Club. They first appeared in 1867.

Douglas became marquess in 1858, at the age of 14. He sat as a representative peer for Scotland in the House of Lords from 1872 to 1880.

Queensberry Rules are a set of rules for boxing matches. They were drawn up under the supervision of the Marquess of Queensberry in 1867. At that time, matches were fought with bare fists. John Graham Chambers, an English athlete, composed the Queensberry Rules to replace the Revised London Prize Ring Rules of 1853. The new rules were first used in 1872 in a tournament in London. They called for three-minute rounds, a one-minute rest between rounds, and the wearing of gloves.

See also **Boxing** (From bare knuckles to gloves); **Queensberry, Marquess of.**

The Great Barrier Reef stretches along the Queensland coast from Gladstone to New Guinea. This huge series of coral formations includes thousands of small islands and many individual reefs.

Queensland

Queensland, the second largest state in Australia, lies in the northeast of the continent. It is sometimes known as the *Sunshine State* because of its pleasantly warm winters and long hours of sunshine. During the winter, Queensland attracts large numbers of tourists from the cooler southern states and from overseas countries. The northern coast is sheltered by the islands and coral reefs of the Great Barrier Reef.

Queensland leads Australia in the production of beef cattle. In northern coastal areas, sugar production is the chief industry. The Darling Downs, in the south, is one of the richest areas in Australia for growing wheat and other grain crops. Queensland's rich mineral resources add to the wealth of the state. Mount Isa has one of the world's most productive copper, lead, and zinc mines. At Weipa, on the Gulf of Carpentaria, is the most extensive deposit of high-grade *bauxite* (aluminium ore) ever discovered. Queensland's Fitzroy River Basin also has vast reserves of high-grade coal.

Queensland was named after Queen Victoria at her own request when the Moreton Bay district separated from New South Wales in 1859. Queensland Day, celebrated on June 6, marks the creation of the new colony.

Facts in brief about Queensland

State capital: Brisbane.
Largest cities: Brisbane, Gold Coast, Townsville, Toowoomba, Ipswich, Rockhampton, Mackay, Cairns, Bundaberg, Mount Isa, Gladstone, Maryborough.
Area: 1,727,200 km²; 2nd largest state.
Population: *1991 census*—2,978,617. 3rd largest state.
Animal emblem: Koala.
Floral emblem: Cooktown Orchid.
Bird emblem: Brolga
State gemstone: Sapphire
Chief products: *Agriculture*—bacon, barley, cattle, cotton, flour, fruit, maize, peanuts, pigs, sheep, sorghum, sugar, tobacco, wheat, wool. *Mining*—bauxite, coal, copper, gold, lead, mineral sands concentrates, nickel, salt, tin, uranium, zinc. *Manufacturing and processing*—bricks, cement, fertilizers, machinery, oil and petrol, textiles, timber products.

Government

The state flag

State coat of arms

Floral emblem
Cooktown Orchid

Symbols of Queensland. The state flag, which bears the Union Jack and the state badge, was adopted in 1876. The state coat of arms depicts a red deer and an Australian crane called a *brolga* supporting the shield. The shield bears cattle, sheep, and grain—symbols of Queensland's agricultural industry—and a column of gold, a pickaxe, and a shovel—symbols of the state's mining industry. The crest above the shield includes a crown, which symbolizes the British monarchy. The Latin motto below the coat of arms means *Bold, Aye, and Faithful, Too.* The coat of arms was adopted in 1883 and redesigned in 1977 in honour of Queen Elizabeth II's visit to Queensland that year.

The government of Queensland consists of a governor appointed by the Queen and an elected Legislative Assembly of 89 members. Bills passed by the Legislative Assembly must receive approval from the Executive Council, which is made up of the governor and the cabinet ministers.

Elections are held every three years. Electoral enrolment and voting are compulsory for all men and women who are over 18 years of age.

Voters must have lived at their present address for the previous three months in order to vote in state elections. They must be Australian citizens by birth or naturalization. The only exceptions are British citizens who were on the state electoral roll at some time between May and August 1983.

Voters elect candidates by voting for them in order of preference. The parties represented in the assembly are the National Party (previously the Country Party), the Liberal Party, and the Australian Labor Party. The party or coalition winning the majority of seats in the assembly forms the government. The leader of the government is called the *premier*. The premier selects ministers, who are then appointed by the governor to administer the affairs of government departments.

There are 18 state government departments. These departments implement the laws and policies of the government and serve the needs of the people of the state in such areas as education, health, harbours and marine, justice, and mines.

Planning, regional coordination, and environmental control come under the premier's department. Some essential services are provided by independent commissions set up by the government. Electricity, irrigation and water supply, and housing are administered by commissions.

The Queensland government receives revenue from a number of sources, including land tax, stamp duty, mining royalties, and railways. The Australian government provides a major part of government finance in the form of grants.

The units of local government are cities, towns, and shires. Local government units provide for roads, sanitary and health services, parks and gardens, water supply, and sewerage.

The state animal (koala)

The old Parliament House of Queensland opened in 1868. A parliamentary annexe behind it opened in 1979.

Queensland political map

People

The 1986 census reported that Queensland had a population of 2,587,315. Officials estimated there were about 48,100 Aborigines or part Aborigines living in the state, including about 3,500 Torres Strait Islanders.

About 40 per cent of the state's population lives in the Brisbane metropolitan area and most of the remainder live in cities and towns along the eastern coast. Despite the importance of the primary industries, fewer than two out of every ten people live in rural areas.

There has been a drift of population toward the cities and larger towns because, as farming has become mechanized, farmworkers can find fewer jobs. The most rapidly growing centres are towns associated with mining, such as Mount Isa and Gladstone, and tourist areas, such as the Gold Coast and Cairns.

Education

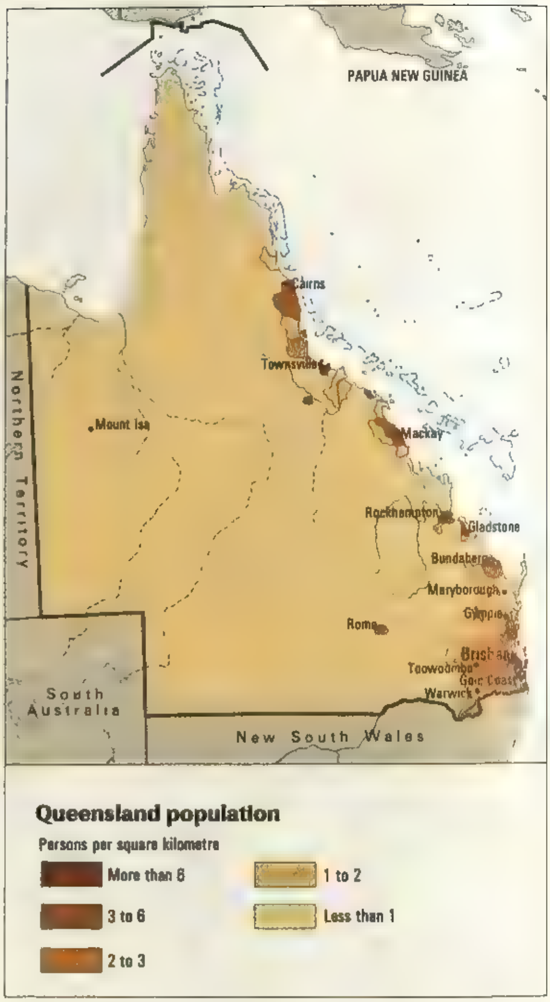
Queensland has a system of free compulsory education for children between the ages of 6 and 15. There are 12 grades, including 7 primary and 5 secondary grades. Most primary education takes place in coeducational state schools. Queensland has about 1,300 primary schools. The state government operates about 80 per cent of these schools. The remaining schools are operated mainly by the Roman Catholic, Anglican, and Uniting churches, particularly the Roman Catholic Church. There are, however, a number of primary schools operated by nondenominational groups.

Queensland also has special schools for handicapped children. Children in sparsely populated areas receive instruction from a correspondence school. A School of the Air operates through the Flying Doctor radio networks from Mount Isa, Charleville, Charters Towers, Cairns, and Longreach. Educational programmes are also transmitted to remote centres by satellite.

Queensland has about 150 state secondary schools and about 80 nonstate secondary schools. In some of the less populous centres, primary schools have secondary departments that offer three or five years of secondary education. All state secondary schools are coeducational but many of the independent schools are for either boys or girls only.

Children at secondary schools receive a junior certificate at the end of the third year and a senior certificate at the completion of the fifth year. These certificates are issued by the Board of Secondary School Studies. There are no statewide examinations for these certificates, but a moderation system ensures that standards are comparable statewide. Every student in his or her 12th year sits for the Australian Scholastic Aptitude Test (ASAT). On the basis of this test and school marks, eligible students are assigned a Tertiary Entrance (TE) score that can determine whether or not they are admitted to universities and colleges of advanced education.

Queensland has 31 colleges of technical and further education and 5 colleges of advanced education. There is an agricultural college at Gatton and pastoral colleges at Longreach, Emerald, Dalby, and Claredale, near Townsville. Queensland and Griffith universities are in Brisbane. The James Cook University of North Queensland is at Townsville. Bond University, which opened in 1989, is on the Gold Coast.



Queensland map index

Cities and towns

Atherton*	9,519	D	4
Ayr	8,639	F	5
Barcaldine	1,813	G	4
Beaudesert*	16,041	J	8
Beenleigh*	7,635	J	8
Biloela	6,174	H	7
Birdsville		I	2
Blackall	2,043	H	4
Blackwater	7,029	H	6
Bongaree*	5,620	I	8
Bowen	14,158	F	6
Brisbane	1,334,746	J	8
Buderim*	5,390	I	8
Bundaberg	48,530	H	7
Caboolture*	3,575	J	8
Cairns	49,334	D	5
Caloundra*	53,765	I	8
Charleville	3,588	I	5
Charters Towers	9,017	F	5
Childers	1,409	H	7
Chinchilla	5,534	I	7
Clermont	2,452	G	5
Cloncurry	3,375	F	2
Collinsville	3,173	F	6
Cooktown	964	D	4
Coolangatta*	6,321	J	8
Cunnamulla	1,697	J	5
Dalby	9,384	I	7
Emerald	10,662	G	6
Gatton*	13,821	I	7
Gayndah	2,848	I	7
Gladstone	24,205	H	7
Gold Coast	157,859	J	8
Goondiwindi	4,330	J	7
Gordonvale	2,341	D	5
Gympie	10,786	I	8
Hervey Bay*	30,867	H	8
Home Hill	3,286	F	5
Hughenden	1,791	F	4
Ingham	5,202	E	5
Innisfail	8,113	E	5
Ipswich	73,310	I	8
Jandowae	863	I	7
Kingaroy	10,394	I	7
Longreach	4,368	G	4
Mackay	52,927	F	6
Mareeba	17,135	D	4
Maroochydore-Mooloolaba*	20,635	I	8
Mary Kathleen		F	2
Maryborough	22,982	H	8
Millmerran	3,014	J	7
Mitchell	1,212	I	6
Monto	3,058	H	7
Moranbah	6,883	G	6
Mossman	1,637	D	4
Mount Isa	24,718	F	2
Mount Morgan	3,093	H	7
Moura	2,808	H	6
Mundubbera	2,340	H	7
Murgon	4,473	I	7
Nambour	9,579	I	8
Nanango	6,736	I	7
Oakey	3,279	I	7
Proserpine*	2,762	F	6
Ravenshoe	986	E	4
Redland Bay	1,718	J	8
Richmond	1,108	F	3
Rockhampton	59,418	G	7
Roma	6,220	I	6
Saint George	2,323	J	6
Sarina	8,073	F	6
Stanthorpe	9,561	J	7
Surfers Paradise*	22,484	J	8
Tewantin-Noosa	11,296	I	8
Texas	817	J	7
Thursday Island*	2,646	A	3
Toowoomba	81,011	I	7
Townsville	87,268	E	5
Tully	2,575	E	5
Warwick	10,395	J	7
Weipa	2,406	B	3
Winton	1,878	G	3
Yeppoon	6,452	G	7

*Does not appear on map; key shows general location.
Source: 1991 census preliminary figures; 1986 census for smaller places.

Cairns, in northern Queensland, enjoys many hours of sunshine. The city is in the tropics and receives heavy rainfall from December to March.

Queensland is noted for its seaside resorts, many of which lie near the main coastal towns. The major resort centre is the Gold Coast, which is just 80 kilometres south of Brisbane. Along the Gold Coast are located some of Queensland's best-known surfing beaches. Two well-known surfing beaches are Burleigh Heads and Coolangatta. The major centre for southern and international tourists is Surfers Paradise. At a similar distance north of Brisbane are the Sunshine Coast beach resorts.

In recent years, tourist facilities have been established on the large sand islands—Bribie, Moreton, and North Stradbroke—that enclose Moreton Bay. This sheltered bay offers excellent facilities for boating and fishing. Yachting and windsurfing are popular summer sports, both on the bay and on the Brisbane River. Water-skiing on the river, on coastal lakes, and on water storage areas also attracts many followers.

Another cluster of beach resorts is located at Hervey

Wallaman Falls, in northeastern Queensland, is one of the highest waterfalls in the world. The 280-metre waterfall drops in two stages. It is located on Stoney Creek, near Ingham.

The Gold Coast, south of Brisbane, is one of the most popular tourist resorts in Australia. Its attractions include dolphin displays and other water activities.

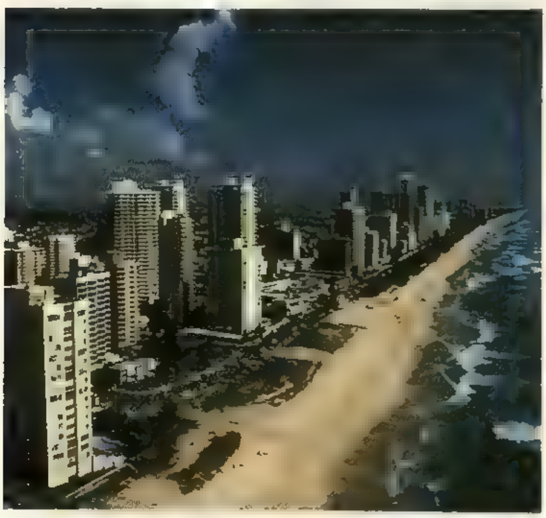
Bay, 35 kilometres from Maryborough. Further north are the resorts of Yeppoon and Emu Park. These two resorts provide recreational facilities for the central Queensland city of Rockhampton.

From Gladstone and the ports to the north, tourist launches carry visitors to the holiday centres on the islands in the waters of the Great Barrier Reef. The best known of these resorts are in the Whitsunday Island group, which is reached by launch from either Mackay or Shute Harbour.

The city of Cairns, on Trinity Bay, is noted for its excellent deep-sea game fishing. Visitors to Cairns also enjoy the lush forests and attractive scenery of its nearby mountains. The people of Queensland are keen players and followers of cricket and tennis. The state has four codes of football and plays cricket in the Sheffield Shield competition.

Many Queensland national parks have graded walks laid down by the Forestry Department. The best-known walks are on the Lamington Plateau, just north of the New South Wales border; at Cunningham's Gap National Park; in the Eungella Range, inland from Mackay; and in the Bunya Mountains, near Dalby. Carnarvon National Park in the central highlands is noted for its spectacular sandstone gorges and Aboriginal stencil paintings.

Some towns in Queensland hold festivals each year. Many tourists go to Toowoomba to enjoy its Carnival of Flowers. Bundaberg holds an annual Sugar Festival, and visitors to Brisbane may take part in the Warana Festival, held each September. Queensland also has a series of popular rodeos. Two of the most notable of the rodeos are the Rocky Round-up, at Rockhampton, and the Bushman's Carnival, at Warwick. Coach tours also take tourists to see the grain harvests on the Darling Downs and the cane fields of the sugar districts.



The Gold Coast, south of Brisbane, has some of Queensland's best-known surfing beaches and many tourist hotels.

Brisbane was selected to host World Expo 88. The site chosen for the 1988 exposition was on the south bank of the Brisbane River, opposite the heart of the city. The theme of World Expo 88 was *Leisure in an Age of Technology.*

Brisbane has several buildings of historical interest. The Windmill in Wickham Terrace and the Commissariat Store are the only buildings that remain from the original convict settlement. The state has restored Old Government House, Parliament House, the Mansions, and Harris Terrace. Other buildings in the capital and in regional centres are being carefully preserved. Wolston House is a private residence that was built in the 1840's. It is administered by the National Trust. Newstead House, built in 1846, is a museum run by the Royal Historical Society of Queensland. Ormiston House, near Cleveland, was the home of Louis Hope, a sugar industry pioneer.

Queensland has its own ballet company, an opera company, a professional theatrical company, and vigorous little-theatre groups. Many cities have their own music contests. Each Easter, a state eisteddfod is held that emphasizes choral singing. Similar annual festivals take place for brass and pipe bands. The state is well served by national and commercial radio stations. Brisbane has five television stations, and others operate in the country. The Queensland Symphony Orchestra receives support from the Australian Broadcasting Corporation, the state government, and the Brisbane City Council.

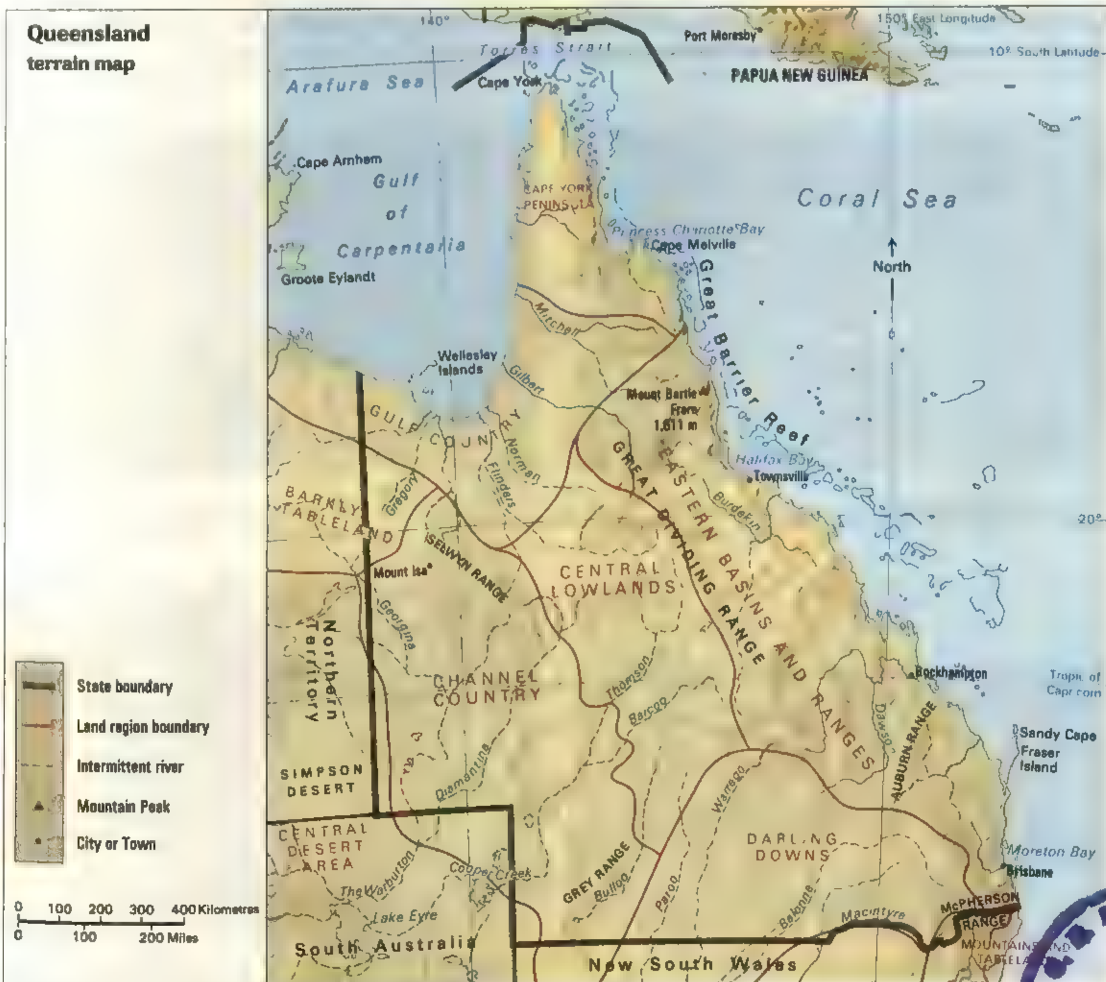
The curtain fig tree attracts many visitors to the lush tropical growth of Queensland's national parks.

Location and size. Queensland occupies the northeastern corner of the Australian continent. The state is roughly triangular in shape. Its greatest length from north to south is 2,090 kilometres, and its greatest width is a little over 1,500 kilometres. The state has a coastline of 5,208 kilometres.

Land regions. Extending north to south through Queensland, a highland belt divides the east coast streams from those of the inland and the Gulf Country. To the east of this divide, the country is made up of dissected plateaus, ranges, and basins. To the west of the divide, the landscape is dominated by wide-open, gently sloping plains.

Eastern Basins and Ranges include the highest mountains of Queensland in the Bellenden Kerr Range. This range is less than 24 kilometres inland from the coast between Cairns and Innisfail. The highest mountain is Mount Bartle Frere, at 1,611 metres. Immediately west of these mountains lies an area of high plateau country drained by several coastal rivers, including the Barron, Tully, and Herbert. These plateau and mountain areas receive a high rainfall and support lush forests. In the

The Darling Downs, a tableland region in southeastern Queensland, is one of the most fertile areas in the state. The region is noted for its wheat production.



Adapted from *Regional Landscapes of Australia.* ©1971 Nancy and Andrew Learmonth.

centre of this region is the Atherton Tableland, an attractive area with several cones and craters left from past volcanic activity. Its red basaltic soils are extremely fertile.

The northern sugar coast of Queensland is the wettest area of Australia. Rainfall throughout this section averages more than 2,000 millimetres a year. The Burdekin River, which flows through this region, has the greatest discharge of any Queensland river system. Loads of sediment, washed down in the frequent summer floods, add to the large Burdekin delta. The midland sugar coast, like the northern sugar coast, is an area of high, forest-covered ranges with heavy rainfall. The major river of this region is the Pioneer.

The Fitzroy is the largest of the coastal basins. The Great Divide is farthest inland in this region. There are vast reserves of high quality coal throughout the basin.

The Mary River drains well-watered hill and mountain country. The larger Burnett Basin is an area of undulating plains and low residual ranges.

Fraser Island, which encloses Hervey Bay, is probably the world's largest sand island. The island is about 120 kilometres long and 15 to 25 kilometres wide. It covers a total area of more than 1,500 square kilometres. There are more than 40 freshwater lakes on the island. The northern third of the island is a national park and the southern two-thirds consists of state forest.

The Brisbane River begins to the west of the D'Aguilar Range and winds south through the Esk rift valley before breaking through the ranges to flow out to Moreton Bay. Tributaries of the Brisbane River drain the fertile farming areas of the Fassifern Valley and Lockyer Plain.

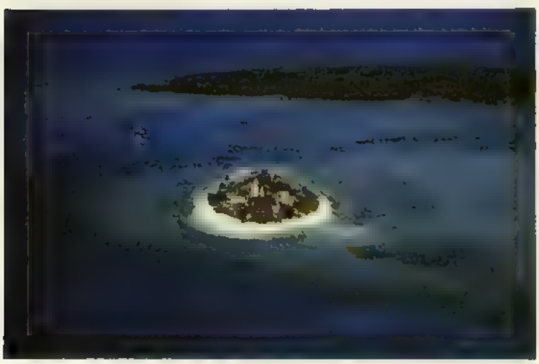
Cape York Peninsula consists of undulating country with savanna vegetation. The highest land is the McIlwraith Range, at 810 metres. All the major rivers of the peninsula, except for the Normanby, flow west to the Gulf of Carpentaria.

The Gulf Country consists of plains surrounding the Gulf of Carpentaria. This land is extremely flat and has a margin of mangrove swamps and salt flats. The large gulf rivers, such as the Flinders, often flood across these broad plains in the summer monsoon season. The natural vegetation is open forest.

The Central Lowlands is the area of the Mitchell grass plains. The country is flat and generally featureless except for the wandering lines of trees following the river channels. River flow is intermittent, but there are large permanent waterholes.

The Darling Downs slope gently from the Main Range to the flat Condamine Plain. The red basalt soils of the east and the deep alluvial clays of the Condamine Plain are excellent for cultivation.

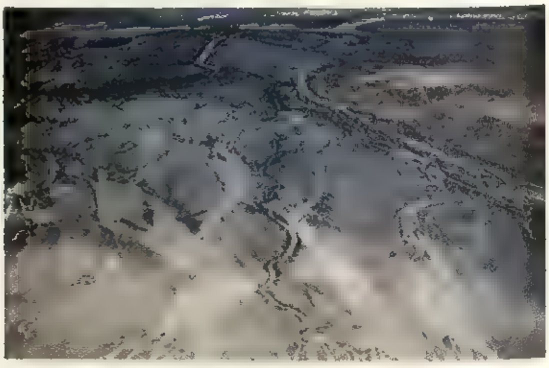
The Barkly Tableland is a flat and treeless limestone



The coastal region of northern Queensland includes small islands such as Lowe Island, off Port Douglas.

The Gulf Country in northern Queensland includes the Norman River, which flows into the Gulf of Carpentaria.

Atherton Tableland is a rugged area of high land averaging 760 metres above sea level. The tableland is in northern Queensland, about 100 kilometres from Cairns.



The Channel Country in central Queensland is a low area that is cut into channels when rivers in the region, such as the Barcoo and Diamantina, flood after heavy rain.

plateau that extends into the Northern Territory. This landscape is dry for most of the year, but late summer rains may transform it into grassland.

The Channel Country is the arid southwest corner of Queensland. It covers almost one-fifth of the state. The name of this region refers to the great network of braided channels through which the rivers, such as Cooper Creek and the Diamantina, make their way toward Lake Eyre. These rivers flow only when heavy rains fall. At most times the channels are dry and sandy.

Rivers, lakes, and wells. Rain falls mainly in the ranges and lowlands of the east and north of Queensland. As a result, most of the permanent streams are in the coastal districts. The only large lakes are reservoirs that were artificially created.

Lake Barrine and Lake Eacham are two small, deep crater lakes on the Atherton Tableland. The Great Artesian Basin underlies the lowlands of western and northern Queensland and provides much of the state with *stock water* (water for livestock).

Climate

Queensland lies within the tropics and subtropics and has a fairly varied climate. Thursday Island, which lies in the Torres Strait off Cape York in the north, has an average monthly temperature of 27° C. Brisbane, in the south, has average temperatures ranging from about 16° C in winter to about 25° C in summer. The coldest area in Queensland is the Granite Belt, where winter temperatures average about 7.7° C. Severe frosts and occasional snowfalls occur there.

Queensland receives most of its rain from December to March. The southeast trade winds carry moisture from the Pacific Ocean onto the coastal areas. Rainfall is heaviest in the northeast, where high mountain ranges are close to the coast.

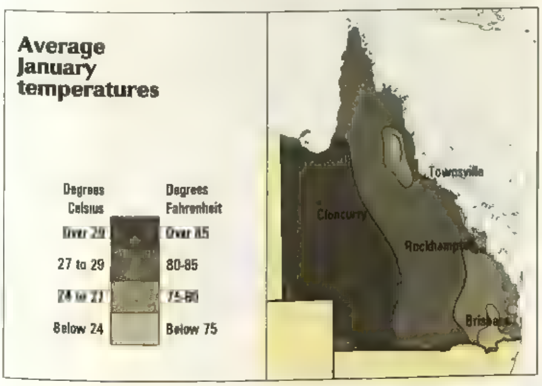
The coastal strip from Ingham to Port Douglas is the wettest part of Australia. Tully has an average rainfall of about 4,570 millimetres. Farther inland, the rainfall decreases. The Channel Country receives less than 250 millimetres a year.

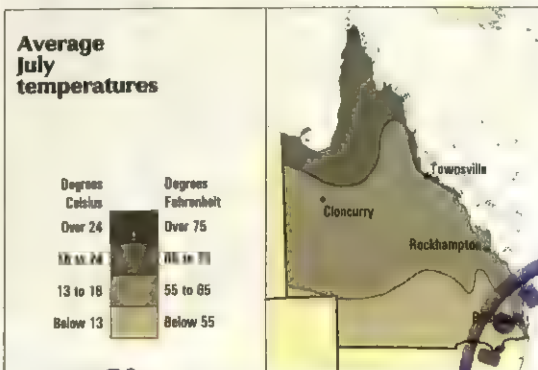
The northern part of the state receives rain associated with summer monsoon conditions. Heavy rainfall also occurs with tropical cyclones, which may bring gale-force winds and cause great destruction in coastal settlements.

Queensland's climate has earned it the name of the *Sunshine State.* People swim on the Great Barrier Reef all year.

Average monthly weather

	Brisbane						Cloncurry					
	Temperatures C° High	Temperatures C° Low	Temperatures F° High	Temperatures F° Low	Days of rain		Temperatures C° High	Temperatures C° Low	Temperatures F° High	Temperatures F° Low	Days of rain
Jan.	29	21	85	69	13	Jan.	41	26	105	78	10
Feb.	29	21	84	69	13	Feb.	37	25	98	77	9
Mar.	28	19	82	67	15	Mar.	31	23	88	73	6
Apr.	26	17	79	62	12	Apr.	27	18	81	64	3
May	23	13	74	56	9	May	27	12	80	54	2
June	21	11	69	51	8	June	23	10	74	50	1
July	21	9	69	49	7	July	24	9	75	49	1
Aug.	22	10	71	50	7	Aug.	29	13	84	56	1
Sept.	24	13	75	55	8	Sept.	33	16	91	60	1
Oct.	26	16	79	60	9	Oct.	37	19	99	67	3
Nov.	28	18	82	64	10	Nov.	37	21	98	69	4
Dec.	29	19	85	67	12	Dec.	39	23	103	74	6





Economy

Queensland depends on agriculture for much of its wealth. The state's main industries are concerned with processing its agricultural produce. But manufacturing provides most of the jobs in the state because only one person in 10 works on a farm, and even fewer people work in the state's mining industry.

Minerals are Queensland's most valuable exports. Coal is the most valuable mineral mined in Queensland, followed by copper and lead. Sugar exports account for about a tenth of the state's exports. Japan is Queensland's main customer, followed by Britain and other members of the European Community. Queensland's imports from overseas include machinery and transport equipment, such as cars. The main suppliers of Queensland's imports are Japan, the United States, and Britain.

Natural resources. Queensland is well endowed with natural resources that provide the basis for both a prosperous economy locally and an important export trade. Coal is the major export, and large quantities of it are also used for the production of electricity in Australia. Other major exports are metal ores and concentrates, meat, cereal grains, sugar, and wool.

The main agricultural soils are black, grey, and brown cracking clays, which occur over large areas in the central and southern subcoastal districts. These soils enable winter crops to be grown in a summer rainfall environment by conserving moisture for later use by the plant. They are moderately fertile. Small areas of highly fertile red volcanic soils occur along the eastern highlands, mainly in the South Burnett and Atherton Tablelands districts, and in some coastal areas. Except for these areas and the rich alluvial soils of the coastal river valleys, most soils along the humid eastern section of the state are poor and only support crops if rainfall is sufficient or if irrigation is available.

Queensland rainfall is sufficient for crop production only in the southeastern part of the state and in the tropical coast and highlands. Rain falls mainly during the summer, but winter rains fall in the southern part of the state. The north suffers an annual drought during winter months. Rainfall is often heavy, and the high runoff, which causes erosion and flooding, is a constant hazard in farming areas and river valleys.

Farming provides much of Queensland's wealth. One out of every 10 people works in agriculture. Of the total state area of 173 million hectares, 155 million hectares are used for grazing and 3 million hectares are used for growing crops. Over 4 million hectares of grazing land have been sown with introduced pasture species.

A wide range of crops can be grown in Queensland because the state extends from tropical to subtropical and temperate latitudes. Cereals are the most important group of crops grown in the state. They include wheat, sorghum, barley, and maize. Other important crops include sugar cane, fruit and vegetables, oilseeds, cotton, tobacco, and peanuts.

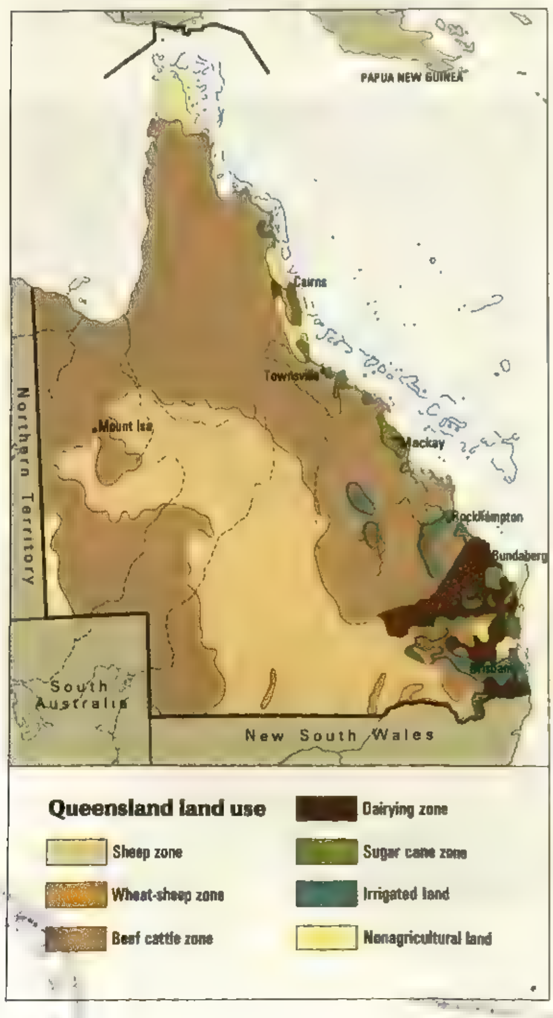
Queensland's largest rural industry is the raising of beef cattle for meat production. Cattle are grazed throughout the state, but the industry is concentrated in eastern central Queensland, where large areas of brigalow (acacia) scrub have been cleared and sown with introduced pasture species.

The earlier British breeds of cattle, such as the Shorthorn and Hereford, have been largely replaced by Zebu or Brahman breeds in the northern and eastern parts of the state. These breeds are more resistant to cattle ticks, which are pests in tropical grazing areas. Significant numbers of cattle are grazed in remote areas, necessitating investment in beef roads. Large road trains carry cattle long distances on these roads to fattening areas and to meatworks along the eastern seaboard.

Sheep grazing for wool production is an important industry on the dry inland plains of southern and central Queensland. The excellent natural grasslands in this region, combined with an adequate stock water supply from artesian basins, provide stability to this extensive grazing industry.

Dairy cattle are grazed in the coastal river valleys of the Moreton and Burnett regions and on the eastern Darling Downs. Although once a large butter-producing industry, dairying now produces mainly milk to supply the towns. The Atherton Tableland, inland from Cairns, supports a small tropical dairying industry that supplies fresh milk to centres in north Queensland.

Poultry are raised for eggs and meat. Virtually all meat chickens are produced around Brisbane, where broiler production is the largest rural industry. Eggs are pro-



duced mainly in grain-growing districts. Specialist piggeries also are mainly located in these areas.

Queensland produces about 95 per cent of Australia's raw sugar. The state produces between 3 million and 3.5 million metric tons of raw sugar each year. About 700,000 metric tons are processed for home consumption. The rest is exported. The main overseas buyers are Japan, Canada, China, Korea, Malaysia, Singapore, and the United States. Sugar production is the most highly organized crop industry in Queensland. Cane is grown on small, family farms in coastal areas between Cairns and the southern border of the state.

Temperate fruits, including apples, pears, stone fruits, and grapes, are grown in the Granite Belt. At about 1,000 metres, the Granite Belt is the coolest part of Queensland. Tropical fruits are grown along the coast. Pineapples are grown mainly in areas north of Brisbane and near Rockhampton. Nearly all pineapples are processed at the Northgate Cannery in Brisbane, which is the largest cannery in the Southern Hemisphere. Bananas are grown mainly in the wet tropics south of Cairns and are transported to markets as far away as Adelaide.

Queensland is an important producer of winter vegetables for the eastern states of Australia. These vegetables are produced in irrigated, frost-free coastal districts around Bowen, Bundaberg, and just north of Brisbane. A fast, daily rail service carries fresh produce from Queensland to markets in the southern states. Summer vegetables are produced in the cooler West Moreton, Darling Downs, and Granite Belt districts.

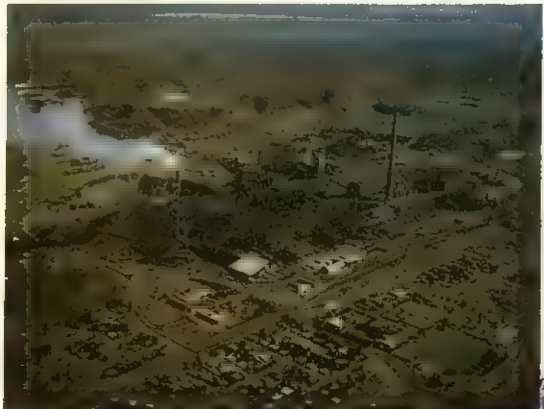
Cotton production, an old industry in Queensland, has undergone a resurgence in recent years with the development of irrigation areas. The main cotton-growing areas in Queensland are the Emerald and St. George Irrigation Areas and the irrigated areas of the Callide, Condamine, and Macintyre river valleys.

Peanuts are grown mainly as a dry-land crop in the South Burnett, around Kingaroy, and on the Atherton Tableland. Oilseeds, such as sunflower seeds, have become an important group of crops in Queensland as a result of the increasing demand for vegetable oils. Sunflowers are grown in central Queensland and on the Darling Downs. Soybeans are grown in the West Moreton districts, mainly under irrigation. A large factory between Brisbane and Ipswich processes a range of oilseed crops.

Bauxite mines at Weipa on Cape York exploit one of the world's largest deposits of this mineral. Bauxite is the ore from which most aluminium is made.

Artesian wells provide water for Queensland's cattle and sheep in many areas. The state has 2,300 artesian bores. They enable farms to operate in dry areas.

Sugar cane grows along almost the entire eastern coast of Queensland from Mossman to the New South Wales border. Queensland produces most of Australia's sugar.



Copper mines at Mount Isa in western Queensland produce almost three-fourths of Australia's copper ore. Mount Isa is one of the world's richest underground mines.

Coal mines at Moura, southwest of Gladstone, produce high-grade coking coal. This coal is taken by rail to the coast for export to Japan.

Beef roads, such as the ones near Winton, in central Queensland, enable growers in remote parts of the state to take cattle to market by truck.

Irrigation schemes have proved useful in Queensland's environment for a number of reasons. The state's warm winters allow out-of-season production of a number of crops under supplementary irrigation. Such crops include tobacco, vegetables, and fodder crops. Crops that require a great deal of water, such as sugar cane, benefit from irrigation in areas where long dry spells are frequent. Cotton has proved highly productive when grown under irrigation in semiarid environments.

The Burdekin River Irrigation Project is the largest irrigation undertaking in Queensland. This irrigation scheme can supply 1,000 million metric tons of water a year to about 45,000 hectares of land. This water benefits sugar cane, rice, and other crops.

Other large irrigation areas that supply water to farmlands in Queensland include Bundaberg, Mareeba-Dimbulah, Emerald, and St. George. These irrigation areas supply more than 230 million metric tons of water to more than 64,000 hectares of farmland. Other important irrigation areas are Eton (Mackay) and Dawson Valley. In addition to these schemes, 17 irrigation projects that use water from government-provided storages have been established. About 200,000 metric tons from these storages are allocated to licensees to irrigate about 44,000 hectares.

Mining is the backbone of the Queensland economy. The state produces more than half the coal exported from Australia, the biggest coal supplier to the world market. Japan is the main coal customer. Coking and steaming coal is also shipped to more than 30 countries in Asia and Europe.

Most of Queensland's coal comes from open-cast mines in the central region of the state, where the main mines are Goonyella; Norwich Park; Peak Downs; Saraji; Blackwater; Moura; Curragh; German Creek; Gregory; Oaky Creek; Riverside; Blair Athol; Newlands; and Collinsville. Coal mined in central Queensland is exported from three ports. These ports are Hay Point-Dalrymple Bay, the largest coal export facility in the world; Abbot Point, near Bowen; and Gladstone. Coal mined in the southern part of the state is shipped through Brisbane.

The Mount Isa Mine is one of the largest underground mines in the world and one of the few mines where the four minerals copper, silver, lead, and zinc are found in proximity. Kidston gold mine, which is 280 kilometres northwest of Townsville, is Australia's largest gold-producing mine.

Manufacturing. Brisbane is the major industrial centre of Queensland. The city has engineering, metal, motor vehicle assembly, and textile industries. Food processing industries include meat packing, fruit canning, sugar refining, and flour milling. There are two oil refineries and two large fertilizer plants. Ipswich is also an important industrial centre. It has brick, pipe, pottery, and butter factories, engineering and fertilizer works, and the state's most important railway workshop.

There are several large mineral processing plants outside the Brisbane metropolitan area, including the copper refinery and the nickel treatment plant at Townsville and the alumina plant and aluminium smelter at Gladstone. Other significant industries outside the Brisbane metropolitan area produce cement, salt, and rum. Other factories process primary raw materials produced in the state, such as sugar, meat, milk, and timber.

Transport and communications. Two long distance luxury trains, the *Queenslander* and the *Sunlander,* operate between Brisbane and Cairns. This service is supplemented by the *Capricornia* service, which runs overnight from Brisbane to Rockhampton. The inland is served by three other passenger trains, the *Inlander* from Townsville to Mount Isa, the *Midlander* from Rockhampton to Winton, and the *Westlander* from Brisbane to Cunnamulla.

All major roads are built by the Main Roads Department of the Queensland state government. The Bruce Highway runs from Brisbane to Cairns along the coast. It is 1,770 kilometres long and has a bitumen surface. The Gateway Bridge, which opened in 1986, enables traffic to bypass the busy Brisbane area.

The two main airlines, Australian Airlines and Ansett Airlines of Australia, serve the main Queensland airports. More than a dozen airlines, including Air Queensland, fly to the smaller towns.

The main ports in terms of the amount of cargo handled are Gladstone, Hay Point, Dalrymple Bay, Brisbane, Weipa, and Townsville. Brisbane handles more vessels than any other port—more than 1,000 each year. The ports of Hay Point, Dalrymple Bay, and Abbot Point were built to handle coal. Mourilyan and Lucinda handle sugar exports. Weipa is a bauxite port.

Aborigines have lived in Australia for at least 50,000 years. They probably came from Southeast Asia at a time when New Guinea was connected to Queensland by a land bridge. At that time, the Gulf of Carpentaria was a huge, salty swamp, and tropical seas were much cooler than today. The oldest Aboriginal relics discovered in Queensland date from about 19,000 years ago. They were discovered in the Kenniff Cave at Mount Moffatt Station in the Great Dividing Range.

Early settlement. A number of historians believe that European navigators first visited the coast of Queensland during the 1500's. These sailors were Portuguese, but few records of this early exploration have been found. The first of the early Dutch voyages to the north coast apparently took place in 1606. In that year, Willem Jansz sailed the *Duyfken* into the Gulf of Carpentaria. He was followed in 1623 by Jan Carstensz, who explored the gulf more thoroughly. The northern coast appeared unattractive for settlement and no suitable anchorages were found.

The British navigator James Cook sailed up the east coast in 1770. Cook made accurate charts and several landings. He first landed at Bustard Bay, at the present site of the small beach resort of Seventeen Seventy. His longest stay was at the Endeavour River, the present site of Cooktown, where he landed to repair his ship after a mishap on one of the reefs.

In 1799, and again in 1802, the British navigator Matthew Flinders sailed the Queensland coast, making accurate surveys. Many of his charts are still used for reference. From 1818 to 1822, Captain Phillip Parker King charted the inner route between the eastern coasts and the Great Barrier Reef.

When Sir Thomas Brisbane arrived from Scotland to become governor of New South Wales in 1821, the existing penal settlements at Port Jackson and Norfolk Island had become overcrowded. In 1822, Commissioner J. T. Bigge suggested moving the most hardened convicts from New South Wales to a new settlement at Moreton Bay. John Oxley, the surveyor general of New South Wales, investigated the area in 1823. Oxley explored the bay in the *Mermaid* and then sailed one of the ship's boats up the Brisbane River as far as the present site of Goodna.

Governor Brisbane believed that the presence of the river would eventually make the area attractive for free settlers and decided to move the convicts to that area. In 1824, Oxley landed Lieutenant Miller, his guards, and convicts at the site he had recommended, Redcliffe Point. The site proved unsatisfactory because it lacked a safe anchorage and was swampy. The group also had trouble with Aborigines.

After two months, the men decided to move the settlement to the present site of Brisbane. This move was completed in the autumn of 1825. The new site had the advantage of an abundance of fresh water. A chain of pools lay along a small valley that met the river near the lower end of what is now Creek Street. The river anchorage enabled ships to be easily docked and unloaded, and it was safer than the open sea. The terraces along the river appeared to be fertile, and the leaders hoped that the new settlers would be able to produce much of their own food.

But the new settlement proved difficult to administer because it was so far away from Sydney. The number of convicts in the settlement never exceeded 1,100, and numbers dropped off during the 1830's. Authorities in Britain opposed the continuation of the convict system and showed an increasing interest in free settlement of New South Wales. John Dunmore Lang visited Brisbane in 1845. He proposed that assisted migrants be brought in and transportation of convicts abolished. There was a restriction on settlement within 80 kilometres of the penal settlement, but Lang used his influence in New South Wales to obtain permission for Christian missions to be established at Nundah and at Dunwich, on Stradbroke Island.

In 1839, the government of New South Wales decided to remove the last of the convicts and to open the area to free settlement. The first area to attract settlers was the Darling Downs. Allan Cunningham, a botanist, discovered the downs in 1827 when he journeyed from the Hunter Valley. Cunningham brought back glowing descriptions of the downs country. He reported sighting a

The *Endeavour* landed in 1770 at the Endeavour River near the present site of Cooktown. The British explorer James Cook beached the ship for repairs after it was damaged on a reef.

Brisbane was painted by the early Australian artist Conrad Martens when he visited the settlement in 1852. At that time, Brisbane was a small settlement with narrow, muddy streets.

gap in the ranges to the east of the downs and proceeded to Moreton Bay in 1828 in order to explore this route. On his first attempt, he was accompanied by Captain Logan, then commandant of the settlement. The two men were unsuccessful. Cunningham tried again, setting out from Limestone Hills (now Ipswich) at the head of navigation on the Brisbane River. He climbed through the gap in August 1828. Exploration continued, and reports of the good grazing land went back to Britain.

Patrick Leslie and his brothers arrived on the Darling Downs in 1840 with sheep they had brought overland with great difficulty from the south. Practically the whole of the Darling Downs area was taken up by squatters in 20 months, and two roads opened through the range to the Moreton district.

When the ban on settlement within 80 kilometres of Brisbane was lifted in 1842, there was a rush to take up the fertile lands of the Moreton lowlands. The Beaudesert, Fassifern, Lockyer, and upper Brisbane areas were settled before 1850.

Growth of the colony. On Dec. 10, 1859, the Moreton Bay district was separated from New South Wales and made into the colony of Queensland. Brisbane became the capital of the new colony. The colony had a governor, a nominee Legislative Council, and an elective Legislative Assembly. The first governor was Sir George Bowen and the first premier, R. G. W. Herbert. At the time, the colony had a population of 23,520, not counting the Aborigines.

Exploration had continued during the 1840's and 1850's. Ludwig Leichhardt carried out his famous overland expedition to Port Essington in 1844 and 1845. Sir Thomas Mitchell explored western Queensland in 1846, and Edmund Kennedy made his epic journey to Cape York in 1848. The squatters soon followed the explorers. By 1865, the new arrivals had reached both Cape York Peninsula and the western border.

The colonial government passed laws to provide for closer settlement. It encouraged settlers to grow cotton. When the United States began to export cotton again after the American Civil War, interest turned to sugar cane production. The first cane plantation in the colony was established by Louis Hope at Ormiston in the Redland Bay district in 1864. This industry was soon to become the main source of wealth for the new colony.

During the 1870's, the rush for sugar lands in the fertile coastal districts began. Settlers took up land in the Burnett River delta and Maryborough district in 1874. Others established their plantations in the Mackay, Cardwell, and Cairns areas. By 1880, 83 small sugar mills were operating in Queensland. The plantation owners brought people from the Pacific Islands to Queensland to work in the fields. The first of these islanders, called *Kanakas,* were brought to Queensland by Robert Towns to work on his cotton plantation on the Logan River. Soon this cheap source of labour was exploited to benefit the sugar industry.

Gold was discovered at Gympie in 1867, and the first gold rush in Queensland began. Other discoveries followed at Charters Towers, in 1872, and at the Palmer River, inland from Cooktown, in 1873. With the influx of diggers, the population grew rapidly, and the colony had 173,000 people by 1876. Gold was discovered at Mount Morgan in 1882.

Regional development. Development of the Fitzroy region began when the Archer family settled at Gracemere, near the present site of Rockhampton, in 1853. They overlanded their livestock from their settlement in the Eidsvold area in the Burnett district.

The real pioneers of Queensland were the settlers of the inland. Before the railways were built, horses, oxen, mules, and even camels were used to haul wagon loads of up to 14 metric tons. A trip to the coast from a town in the far west took several months. The first railway was built from Ipswich to Granchester in 1865. It reached Toowoomba and the Darling Downs in 1867. The railway from Rockhampton to Longreach was completed in 1892, and the coastal link from Brisbane was completed in 1897.

In 1901, Queensland joined with the other colonies to form the Commonwealth of Australia. Throughout the 1900's, Queensland's population grew steadily and the state continued to make economic progress, particularly after World War II.

Related articles in *World Book* include:

Biographies

Archer	Cunningham, Allan	Lang, John Dunmore
Bowen, Sir George	Flinders, Matthew	Lockyer, Edmund
Brisbane, Sir Thomas	Griffith, Sir Samuel Walker	Logan, Patrick
Carstensz, Jan	Jansz, Willem	Oxley, John
Cook, James		Towns, Robert

Cities and towns

Brisbane	Ipswich	Surfers Paradise
Bundaberg	Mackay	Toowoomba
Gladstone	Maryborough	Townsville
Gold Coast	Mount Isa	Warwick
Innisfail	Rockhampton	Weipa

Outline

I. **Government**
II. **People**
III. **Education**
IV. **Visitor's guide**
V. **Land**
   A. Location and size
   B. Land regions
   C. Rivers, lakes, and wells
VI. **Climate**
VII. **Economy**
   A. Natural resources
   B. Farming
   C. Irrigation schemes
   D. Mining
   E. Manufacturing
   F. Transport and communications
VIII. **History**
   A. Aborigines
   B. Early settlement
   C. Growth of the colony
   D. Regional development

Questions

When did the first Europeans visit Queensland?
Where were the oldest Aboriginal relics in Queensland discovered?
When were the last convicts removed from the colony?
What was the main source of wealth in the new colony?
When does Queensland receive most of its rain? Where?
Where are Queensland's surfing beaches located?
What are the duties of Queensland's 18 government departments?
What is the climate of the Barkly Tableland?
Why are irrigation schemes so useful in Queensland?
Which country is the main customer for Queensland's coal?

Queensland blue heeler. See Australian cattle dog.

Quemoy is the name of a group of islands about 8 kilometres off the coast of China, in the Taiwan Strait. *Quemoy* is also the name of the largest island in the group. The Chinese call this island *Jinmen.* For location, see Taiwan (map).

The Quemoy islands have a population of about 48,000 and an area of 150 square kilometres. The Chinese Nationalist government continued to control the islands after the Chinese Communists conquered mainland China in 1949. The Chinese Communists bombarded the islands with artillery fire heavily in 1958 and occasionally during the 1960's. They officially announced a cease-fire in 1979.

Querétaro is a mountainous state in central Mexico (see Mexico (political map)). It has a population of 1,051,235 and covers 11,449 square kilometres. Farm products include wheat, maize, beans, and lentils. Mines there produce opals, silver, gold, lead, and copper. The city of Querétaro is the capital. The Mexican Constitution was drafted in the city in 1916 and 1917. Querétaro is one of the original Mexican states.

Quesnay, François (1694-1774), was a French economist who made some of the earliest contributions to the development of economics. He headed a group of economic writers called the *physiocrats.* The physiocrats believed that natural laws direct economic activity, and they tried to discover these laws. They devised early forms of economic *models,* charts or sets of formulas showing the relationships between various parts of a nation's economy.

Quesnay developed the idea that wealth flows continuously between producers and consumers. He and his followers considered land to be the only source of wealth. Only agriculture, they believed, could yield products of greater value than the resources used for production. In a chart called the *Tableau Économique* (1758), Quesnay traced the relationships between different economic classes, such as farmers and merchants. He showed how the wealth created by agricultural production circulates throughout the economy.

Quesnay was born in Méré, near Paris. Before taking up economics, he studied medicine and was the personal doctor of King Louis XV of France.

See also **Physiocrats.**

Question mark. See Punctuation.

Quetta (pop. 285,719) is a city in western Pakistan. It lies about 590 kilometres northwest of Karachi. For location, see Pakistan (political map). Quetta is an important military station and trade centre. It is on the direct route from Karachi to southern Afghanistan. Traded goods include fruit, wool, carpets, and leather. The University of Baluchistan is located at Quetta.

The British acquired Quetta by treaty in 1876. The city was severely damaged by an earthquake in 1935.

Quetzal is a brilliantly coloured bird of the trogon family (see **Trogon**). There are four species of quetzals. They are found in Central and South America. The head, back, and chest of the *resplendent quetzal* of Central America are glittering emerald-green, and the underparts are crimson. The head has a wide crest of golden-green, hairlike feathers. The upper tail feathers are enormously developed and form a train about 90 centimetres long. The brown and buff-coloured female has no long tail feathers. As in trogons, the quetzal's feet are small and weak. The bird sits quietly for long periods on a perch in dense forest. It builds its nest in a hole in a tree.

Ancient Maya chiefs used the long tail feathers of the quetzal as a symbol of authority. One of the legends about this bird says that it loves freedom too much to survive captivity. The quetzal is the national bird of Guatemala, and appears on that nation's postage stamps.

Scientific classification. Quetzals belong to the trogon family, Trogonidae. The resplendent quetzal is *Pharomachrus mocinno.*

See also **Bird** (picture: Birds of Central and South America).

Quetzalcóatl. See **Aztec** (Religion; picture: Aztec writing); **Mythology** (American Indian mythology; picture); **Orozco, José Clemente** (picture).

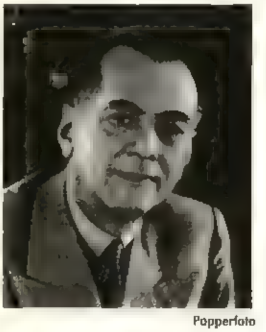
Quevedo, Francisco de (1580-1645), was the leading Spanish humanist of the 1600's. He wrote extensively on social, political, religious, and aesthetic problems of Spanish Renaissance life. His works include *Life of the Swindler* (1626), a cruelly ironic picaresque novel; *Visions* (1627), a satirical prose portrait of Spanish society; and hundreds of poems on moral and sentimental themes. His political ideology, expressed in the *Politics of God* (1626) and other works, was modelled on the life and teachings of Christ and contrasted with the harsh realities of Spanish court intrigue. Quevedo's theological and philosophical essays generally reflect an ascetic and stoic point of view.

Quevedo was born in Madrid. His bitter satires caused him much personal trouble. He was jailed from 1639 to 1643 as the supposed author of verses ridiculing corruption in the court of King Philip IV.

Quezon, Manuel L. (1878-1944), served as first president of the Philippines Commonwealth from 1935 until his death. In 1934, he sponsored the Philippine Independence Act, which the United States Congress passed to establish the Commonwealth of the Philippines. The next year Quezon was elected president.

When the Japanese invaded the Philippines in 1941, Quezon was forced to retreat to Corregidor. He escaped by submarine in 1942 and established a government in exile in the United States. In 1944, he died of tuberculosis in Saranac Lake, New York. His body was brought back to the Philippines and buried in Quezon City, which is named in his honour.

Manuel Luis Quezon y Molina was born in the eastern coastal town of Baler, in Luzon. Both his parents were school teachers. He studied at the Dominican schools in Manila, where he graduated in law. Quezon joined the revolutionary army that fought for independence first against the Spanish rulers of the Philippines and then against the United States. He became an aide to the revolutionary leader General Emilio Aguinaldo. Quezon was jailed because of his part in the rebellion.



Popperfoto

Manuel Quezon

Quezon City is the home of the Philippine Heart Centre for Asia, *left.* The centre has the latest facilities and equipment for the care and treatment of heart ailments and for research into aspects of heart disease. It is one of the finest specialist medical centres in Asia.

In 1905, Quezon ran successfully for election as provincial governor. In 1907, he was elected to the first Philippine Assembly. He helped to found the Nacionalista Party, which became the dominant political party. From 1906 to 1915, Quezon was Philippine commissioner in the U.S. Congress. In 1916, a law was passed creating a Philippine Senate. Quezon became president. He held this post until 1934 when he was elected president of the newly-created Philippines Commonwealth government.

Quezon City (pop. 1,666,766) is a beautiful city in the Philippines. It lies 16 kilometres northeast of Manila. For location, see **Philippines** (political map).

The city is named after Manuel Luis Quezon, the first president of the Commonwealth of the Philippines, who died in 1944. It was officially the capital of the Philippines from 1948 until 1976 when Manila again became the official capital. Today Quezon City is part of *Metro Manila,* the Philippine Capital Region.

From the time of its founding until the present, Quezon City has grown rapidly. It now covers an area of land more than four and a half times that of Manila. This rapid growth has led to its becoming a government, educational, commercial, and recreational centre which is still developing.

Buildings. Towering above Quezon City is the Quezon Monument, which thrusts more than 30 metres upwards into the sky. Its base is a *mausoleum* (large tomb) housing the body of Manuel Luis Quezon. The Quezon City Museum and Art Gallery is located in underground chambers inside the mausoleum. The monument and the road that encircles it is now known as the Quezon Memorial Circle. A 26-hectare park is being built within it to house the world's largest coloured fountain.

Quezon City has many imposing buildings. The *Batasang Pambansa* (Legislative Building) is located in the city on Constitution Hill. It once housed the nation's main law-making body, the House of Representatives of Congress.

Quezon City Hall, a 14-storey building, is the most imposing local government building in the country. Its beautifully landscaped gardens feature a sunken garden, an orchid garden, and a man-made lagoon.

The University of the Philippines has the largest university campus in the world, covering 500 hectares. The university's avenues, lined with palm trees and flowering plants, are the most beautiful driveways in the city.

The Philippine Heart Centre for Asia has the latest facilities and equipment for the care and treatment of heart ailments. The atomic reactor is the only one of its kind in the country. It signifies the Philippines' involvement in the peaceful uses of nuclear energy.

A number of private buildings in Quezon City are also of outstanding interest. These include the Araneta Coliseum, which seats 25,000 people.

The Iglesia ni Kristo Palace is a church of striking design. The Church of San Francisco del Monte was built over an underground cavern. It is the only church in the country whose patron saint, San Pedro de Bautista, was its former parish priest. The Santo Domingo Church, built on Quezon Avenue, is another imposing structure.

Government. Quezon City is run by a mayor, a vice mayor, and 24 councillors, all of whom are elected. The councillors are made up of six from each of the city's four congressional districts, and they serve as the lawmaking body of the city.

History. Quezon's original plan for the city was that it should have a similar status to that of Washington D.C., in the United States, and serve as the future capital of the Republic of the Philippines. Quezon is regarded by Filipinos as "the father of social justice", and he intended to make the new city a worker's paradise. There, each low-income employee would be offered a home he or she could afford, together with a plot of land.

In 1939, the Philippine government purchased the land where Quezon City now stands. The land was part of a private estate and was bought to serve chiefly as a residential area. Architects prepared a master plan for

the development of the city, but further work was interrupted by the Japanese invasion of the Philippines in 1941. When work was resumed in 1945 at the end of World War II, the plans were modified to meet the needs of a fast-growing community. In 1948, the government officially transferred the capital from Manila to Quezon City. But Manila again became the official capital in 1976.

Quick-freezing. See **Food, Frozen.**

Quicksand is a deep mass of extremely fine sand. It usually forms on the bottoms of streams and on sand flats along seacoasts. The sand body behaves like a fluid because water flowing through the sand forces individual grains apart and prevents them from settling. In the *quick* condition, the sand loses its firmness and cannot support heavy weight. Thick layers of quicksand are dangerous and may cause the death of trapped people.

People caught in deep quicksand must remain calm. They should fall flat on their back with arms stretched out at right angles to the body. In this position, the body will float on the sand. The person should roll slowly off the sand to firm ground. Building on quicksand requires special foundations.

Quicksilver. See **Mercury** (element).

Quill. See **Feather** (Kinds and parts of feathers); **Pen** (History).

Quiller-Couch, Sir Arthur (1863-1944), was a British novelist, essayist, poet, and literary critic. He wrote many of his books under the pen name of *Q.* His best-known novel is *The Astonishing History of Troy Town* (1888), one of many set in his home county of Cornwall. Quiller-Couch was a master of style, and set forth many of his views in *On the Art of Writing* (1916). He compiled many anthologies, including the Oxford books of English verse (1900), ballads (1910), Victorian verse (1912), and English prose (1925).

Quiller-Couch was born in Bodmin, Cornwall, England, and studied at Oxford. He was knighted in 1910. From 1912 until his death, he was professor of English literature at Cambridge University.

Quilt is a cloth bedcover. A quilt consists of two layers of cloth filled with an *interlining* of a soft, insulating material, such as cotton, down, or wool. The layers are fastened by tiny stitches that run in plain rows or in decorative designs. Many beautifully decorated quilts are considered outstanding examples of folk art.

The top layer of a quilt is often decorated with colourful geometric forms or pictures of animals, buildings, people, and plants. Designs may commemorate historic events or important family occasions. A quilt design can be created in several ways. In a *pieced quilt,* the top layer consists of many different pieces of cloth sewn together in a design. An *appliquéd quilt* has cutout designs sewn onto one large piece of cloth (see **Appliqué**). *Cord quilts* and *trapunto-stuffed quilts* feature a raised design produced by cotton cording or padding inserted between the top and bottom layers of cloth.

See also **Folk art** (picture: Household objects); **Hobby** (picture).

Quince is a type of attractive shrub or small tree that is closely related to apple and pear trees. The *common quince* has many large, pinkish-white flowers and twisted branches. Its fragrant, fuzzy fruit is round to pear-shaped and is golden-yellow. The fruit grows up to 7.5 centimetres in diameter and bears many seeds in its core. Botanists call this type of fruit a *pome.* The fruit is hard and has an acid taste and is almost never eaten fresh. It is used in marmalades and jellies, often in combination with other fruits.

The common quince can be grown from cuttings or by *grafting* (joining) a quince seedling to another plant. Buds from pear trees sometimes are grafted to quince rootstocks to produce dwarf pear trees (see **Pear** [How pears are grown]). The common quince has been cultivated since ancient times and was originally grown in central Asia.

Another type of quince, the Japanese *flowering quince,* is a thorny shrub with showy red blossoms. It bears a very sour fruit that grows up to 4 centimetres in diameter.

Baltimore Album Quilt (about 1847 1850); the Baltimore Museum of Art, U.S.A.

An appliquéd quilt has cutout designs sewn onto a large piece of cloth. This one has an embroidered picture of Baltimore's Washington Monument in the third row.

The hard, golden-yellow quince puckers the mouth when tasted raw, but it has a delightful flavour when it is cooked.

Scientific classification. Quinces belong to the rose family, Rosaceae. The common quince is *Cydonia oblonga.* The flowering quince is *Chaenomeles japonica.*

Quinine is a bitter substance that is taken from the bark of the cinchona tree. It is used to treat malaria and other diseases. The trees from which it comes first grew along the eastern slopes of the Andes Mountains in South America. Indians there used the bark as medicine even before the Spanish came in the 1500's. The trees began to die out during the mid-1800's, but other cinchona trees were planted in India and Indonesia, especially Java. Most of the quinine used today comes from Java.

Doctors have used quinine chiefly to suppress attacks of malaria. It reduces the fever during attacks, but does not cure the disease. Quinine is used to treat malaria in many tropical regions where the drug is cheap and easy to obtain. In many countries, however, quinine has largely been replaced by synthetic drugs such as amodiaquine, chloroquine, and primaquine. These drugs are more expensive to produce, but they are much more effective and less dangerous to use against most types of malaria than quinine. In Vietnam, however, doctors have found a type of malaria resistant to modern synthetic drugs. As a result, doctors there are again using quinine.

Doctors today still use the drug *quinidine* to treat and correct certain disorders of heart rhythm. Quinidine has the same chemical formula as quinine, and differs from it only in the way the atoms are arranged in the molecule. Doctors believe quinine and quinidine may cause abnormalities in unborn children. For this reason, pregnant women should not take these drugs without first consulting a doctor.

See also **Alkaloid; Cinchona; Malaria** (Treatment and prevention).

Quintet. See **Classical music.**

Quintilian (A.D. 35?-95?) was a Roman teacher of oratory. He is best known for his 12-volume *Institutio Oratoria* (often called *The Training of an Orator*), a manual for the training of public speakers from infancy to adulthood.

In the manual, Quintilian outlined a programme that combined broad, general education with specialized training in *rhetoric* (the art of persuasion). He stressed that an orator must have both technical ability and moral worth. Quintilian also provided brief judgments regarding the value of many Greek and Latin writers in the training of young orators. Quintilian's manual influenced many later literary figures, especially during the Renaissance.

Marcus Fabius Quintilianus was born in Calagurris (now Calahorra), Spain. He was educated in Rome and became a great teacher of the art of rhetoric there in the A.D. 70's and 80's.

Quintillion is a million million millions in the United States and France. This is the meaning for quintillion used in this encyclopedia. One quintillion is written with 18 zeros: 1,000,000,000,000,000,000. In Australia and Great Britain, one quintillion, in some cases, has 30 zeros. See also **Decimal system** (The decimal system and number words).

Quintuplets are five babies born to the same mother at one time. Some scientists believe that quintuplet pregnancies occur only once in every 15 to 20 million births.

The first quintuplets known to have lived more than a few hours after birth were five girls born to Elzire and Oliva Dionne on May 28, 1934. The Dionne quintuplets were born near Callander, Ontario, Canada.

See also **Multiple birth.**

Quipu. See **Inca** (Communication and learning); **Indian, American** (Writing).

Quirinal Hill is the northernmost of the famous seven hills of Rome. It was named after the god Quirinus (see **Quirinus**).

The Quirinal Hill was originally the home of the Sabines (see **Sabines**). Evidence of their ancient settlement has been found on this hill. There were many famous temples on the hill, including the oldest shrine of the god Jupiter. Julius Caesar had large gardens on the edge of the hill, and the emperor Constantine built a famous public bath there. In the A.D. 1500's, a large palace and garden were built on the hill for the popes. These were later used by the kings of Italy.

See also **Rome.**

Quirinal Palace was the residence of the kings of Italy from 1871 until 1946. It stands on the Quirinal Hill in Rome. Before 1870, the palace was the summer residence of the popes. Gregory XIII began it for that purpose in 1574. In 1948, the palace became the official residence of the president of the Italian Republic. See also **Rome.**

Quirino, Elpidio (1890-1956), was president of the Philippines from 1948 to 1953. He advocated an extensive programme of industrialization during his six-year term. Raymón Magsaysay defeated him in the 1953 elections.

Quirino was born in Vigan, Ilocos Sur province, on the island of Luzon. In 1915, he graduated in law from the University of the Philippines, in Manila. He served as a member of the Philippine House of Representatives from 1919 to 1925, and was a senator from 1925 to 1931.

When the Philippine Commonwealth was established in 1934, Quirino became secretary of finance. During World War II (1939-1945), the Japanese imprisoned him for three weeks on suspicion of guerrilla activities. After the war, he served as vice president under President Manuel Roxas. He succeeded as president when Roxas died suddenly in 1948.

See also **Philippines, Government of the; Philippines, History of the.**

Quirinus was one of the three principal gods in Roman mythology during the early history of Rome. Quirinus, Jupiter, and Mars made up the *archaic triad.* Of this group of three gods, Quirinus was most concerned with the Roman people. He had the basic role of promoting the general prosperity and welfare of the community. Through the years, the people came to believe that Quirinus was the divine *incarnation* (form) of Romulus, one of the mythical cofounders of Rome.

After about 200 B.C., Quirinus lost much of his importance to the Romans. A new *Capitoline triad* emerged, consisting of Jupiter, Juno, and Minerva. But the idea originally represented by Quirinus—divine concern for the people's welfare—remained fundamental to the religion of the ancient Romans.

See also **Mythology** (Roman divinities).

Quirós, Pedro Fernandez de (1565-1615), a Portuguese navigator, sighted Vanuatu in 1606. In Portuguese, his name is spelled *Queirós, Pedro Fernandes de.* He was sailing for Spain in search of the *Terra Australis Incognita* (Unknown Southern Land). He believed that the southernmost island of the group was the tip of a continent. But the largest body of land he found was Espiritu Santo, the biggest of the islands that now make up the nation of Vanuatu. Quirós was born in Evora, Portugal.

Quisling, Vidkun Abraham Lauritz (1887-1945), was a Norwegian traitor of World War II (1939-1945). The word *quisling* came to stand for *traitor* because of his aid to German occupation forces. At the end of the war, Quisling was convicted of treason and shot.

Quisling was born in Telemark. In 1931, Quisling formed his own political party, the National Union. He contacted German Nazi leaders and conferred with Adolf Hitler in 1940. Shortly afterward, the Germans attacked Norway.

Quit India Movement was one of the last organized attempts made by Indian nationalists to expel the British from India. The movement was named after the "Quit India" resolution passed by an All-India Congress committee in Bombay in August, 1942.

During World War II (1939-1945), the United Kingdom needed India's help to repel the invading Japanese. But the Indian National Congress decided their best hope lay in expelling the British altogether from India.

After the "Quit India" resolution was passed, the Indian people began a campaign of passive resistance against the British under the leadership of Mohandas Gandhi. The British arrested Gandhi and other Indian leaders. This shocked Indian patriots into attacks on symbols of British authority, such as police stations.

The government reacted harshly, flogging, fining, and sometimes shooting demonstrators. The movement was soon suppressed, but it had demonstrated the depth and fervour of nationalist feelings.

See also **India, History of.**

Quito (pop. 1,281,849) is the capital of the Republic of Ecuador. It is Ecuador's second largest city and its principal textile centre. It lies almost on the equator, 2,850 metres above sea level in the Andes Mountains. See Ecuador (map).

The name *Quito* comes from the word *Quitus,* the name of an ancient people who lived in Ecuador long before Spanish conquerors arrived in 1534. The Spaniards ruled Quito until 1822, when General Antonio José de Sucre defeated them in the Battle of Pichincha on a mountain slope overlooking the city. The victory helped Ecuador become an independent republic.

Under Spanish rule, Qúito was a great centre of religious art. Many of the city's old churches and monasteries have paintings and sculptures from that period.

See also **Ecuador** (picture).

Quixote, Don. See **Don Quixote.**

Qumran. See **Dead Sea Scrolls.**

Quoits is a game in which players toss a metal ring, called a *quoit,* at a peg, called a *mott.* The mott is level with the ground. A white target about 10 centimetres in diameter surrounds the mott so players can see it.

Rules vary, but in championship competition players toss quoits at two motts 16 metres apart. Each player stands behind one mott and alternately throws two quoits at the other mott. A quoit closer to the mott than an opponent's quoit counts one point. Most games end when a side has 21 points. If the score is tied at 20-20, play continues until one side leads by 2 points.

Quoits vary in size and weight. Those used in championship tournaments weigh 1.6 kilograms and measure 15 centimetres in diameter with a hole 7 centimetres in diameter.

Quokka is a small wallaby with a short tail, small feet, and short ears that barely project above its long fur. Quokkas live mainly in dense, moist vegetation along the southwestern coast of Western Australia.

Scientific classification. The quokka belongs to the kangaroo and wallaby family, Macropodidae. It is genus *Setonix brachyurus.*

See also **Kangaroo** (picture).

Quoll. See **Marsupial cat.**

Quorum is a certain number, or proportion, of members of an organization required by parliamentary law to be present before the group can transact business. In social organizations, the quorum is usually fixed by the constitution or bylaws, and may be less than a majority of the total membership. But in a legislative body, such as a city council, a majority of the members is required in order to form a quorum. A majority is also usually required for a board of managers or trustees of a corporation. A quorum is not needed to debate legislative measures. But a quorum is needed for a vote to be legal.

Quota International is a service organization of executives and professionals who work to help people with hearing and speech disabilities. Its motto, "We Share," is from the Latin word *quota,* meaning *a share.* The organization was founded by Wanda Frey Joiner in Buffalo, New York, in 1919. It has about 12,000 members in approximately 460 clubs in the United States, Canada, Australia, New Zealand, the Philippines, Singapore, India, Sri Lanka, Aruba, Curaçao, and Hong Kong. Headquarters are in Washington, D.C.

Quota system. See **Immigration** (1900-1939. Restrictions on immigration).

Quotation marks. See **Punctuation.**

Quotient. See **Division.**

Quito lies high in the Andes Mountains. The city's skyline is a blend of old tile-roofed buildings and modern skyscrapers.

Quran is the sacred book of the Muslims. It is also spelled *Qur'an* or *Koran.* The name *Quran* means recitation or reading. Muslims believe that God revealed the contents of the Quran to the Prophet Muhammad through the angel Gabriel. The first verses of the Quran were revealed to Muhammad in A.D. 610 and marked the start of his mission to bring Islam to the world (see **Muhammad**). The verses begin: "Recite in the name of your Lord who created . . ."

Quranic passages of various lengths gradually came to the Prophet over the whole period of his mission. This lasted from 610 until 632, the year of his death. His companions learned the passages by heart. Some of them wrote the passages on various kinds of material, such as hide, stone, and bone. The Arabs had a long tradition of learning their history and literature by heart. It was particularly important for Muslims to learn the Quran by heart, and Muhammad read it to them many times throughout the years of his mission.

After Muhammad died, a series of successors ruled the Islamic world. These rulers, who were elected from Muhammad's tribe, were called *Caliphs.* During the reign of Caliph Abu Bakr in 632-634, all the Quranic material was collected into one volume. Twenty years later, under Caliph Uthman, scribes made a number of copies of the volume. The copies were sent to different parts of the Muslim world. The contents of these volumes represent the official version of the Quran and all Muslims recognize its authority.

Muslims believe the Quran to be the words of God Himself, and in no sense the composition of Muhammad. Muhammad's own words were recorded in other writings called the *Hadith.* These are the second most important source of Islamic teachings, and are different from the Quran in style.

The Quran often addresses itself to Muhammad and gives him certain instructions: say or read so-and-so: do this: do not do that. Muslims believe that the speaker in the Quran is God. On many occasions, God says to the Prophet "We sent down the Quran to you."

Form

The Quran was revealed in Arabic, and Muslims regard it as the best writing in Arabic ever produced. Indeed, they consider that no author can ever match it. The Quran, with its language and its message, is for the Muslims the miracle that confirms Muhammad's prophethood.

The Arabic text of the Quran is about 500 pages long. It consists of verses called *ayas,* grouped together in chapters called *suras.* There are 114 chapters of varying length, with some very short ones coming at the end. The longest is Chapter 2. It consists of 286 verses. Each chapter begins with the words: "In the name of Allah, the Merciful, the Compassionate." *Allah* is the Arabic word for God. Muslims refer to the chapters by their names rather than their numbers. Most chapters deal with more than one topic, and some topics are treated in more than one chapter. The names of the chapters are not titles; usually they come from a key word, an event, or a figure mentioned in the chapter. The order of chapters in the Quran does not run according to subject matter. Muslims do not change the traditional order of the chapters, nor of the material within them. This is because they believe that what is in the Quran is the Word of God.

Muslims everywhere must learn and read at least part of the Quran in Arabic. Muslim children start to learn portions of the Quran by heart early in their education. The girls, *left,* are receiving instruction in the Quran in Fatehpur Sikri, Uttar Pradesh, India.

Teaching

The Quran is the highest authority in Islam. It is the first and basic source of the Islamic *creed* (code of beliefs), rituals, ethics, and laws. What Muhammad the Prophet said and did, which was reported in the *Hadith,* comes second to the Quran. It serves to confirm, explain, or build on the Quranic principles. The *Hadith* never contradicts the Quran.

The central teaching of the Quran is that there is only one God. Allah is the creator of the universe. The wonders we can observe around us are presented in the Quran as signs of God's existence and mercy. The Quran speaks at length about these signs and invites the reader to reflect upon them, as in the following examples:

> In the creation of the heavens and the earth, and the alternation of the night and day, and the boats at sea with their loads that benefit mankind, and the water Allah sends down from heaven to bring the earth back to life, and in the animals He spread over the earth, and in the movements of the wind and the clouds between heaven and earth—These are signs for people to reflect upon.
> (2:164)

> He created the animals for you. In them you find warmth, food and other benefits. And in them there is contentment for you.
> (16:5-6)

> There is no animal on earth, nor bird that flies on its two wings, but they are communities like your own.
> (6:38)

> Let man reflect on the food he eats: how We pour down the rain in torrents, then We open the soil for the seeds to grow. How We bring forth the corn, the grapes and the fresh vegetation; the olive trees and the palm trees, the thickets, the fruit-trees and the green pastures for you and for your cattle to enjoy.
> (80:24-32)

The Quran teaches that God created men and women. He requires them to conduct their lives in this world according to what He reveals in His scriptures. He will judge them accordingly on the Day of Judgment. In His mercy He revealed His message to successive prophets, the last of whom was Muhammad. Basically, they all preached the same message.

The Quran contains the stories of many earlier prophets. A Muslim must believe in them all and in what was revealed to them.

> Say: "We believe in Allah and in what has been revealed to us, and what has been revealed to Abraham, Ishmael, Isaac, Jacob and the tribes; to Moses and Jesus and the other Prophets. We make no distinction between them, and to Allah we have surrendered ourselves."
> (2:136)

This article of faith is the first of the "five pillars" of Islam. This and the other pillars—the five daily prayers, the giving of alms, fasting in the month of Ramadan, and making the pilgrimage to Mecca—are all described in the *World Book* article on **Islam.** The Quran teaches

The first page of the Quran, *above,* has only the first half of the *fatiha* (opening). The fatiha is a short prayer in praise of Allah.

honesty, charity, kindness, helping one another to do what is good, aiding the weak and the oppressed, acting with justice and righteousness, and keeping one's duty to God. Repeatedly God addresses the believers in the Quran, but sometimes He addresses a wider audience.

> O mankind, We have created you from a male and a female and made you into nations and tribes, that you might get to know one another. The noblest of you in Allah's sight is he who is most righteous. Allah is all-knowing and wise.
> (49:13)

> We have ordained a law and a path for each of you. Had Allah wished it, He could have made you into one nation, but in order to test your faith in what He has given you He has made you as you are. Vie with one another in good works, for to Allah you shall all return, and He will declare to you what you have disagreed about.
> (5:48)

The Quran is believed by Muslims to contain the words of God as told to the prophet Muhammad. All Muslims are expected to know and read the Quran and boys and men study it particularly intensely. Some men become reciters of the Quran, a respected profession in Islamic culture.

Islam is a complete system of life for Muslims. The Quran contains regulations for daily life and laws on various matters such as marriage and family life, commercial life, government, and international relations.

The Quran and Muslim culture

The collected written text of the Quran was the first book ever produced in the Arabic language. The various branches of Arabic studies developed originally for the sake of the Quran and its correct interpretation, or understanding. Arabic grammar and phonetics, for example, developed so that people might not make mistakes in reading the Quran. *Calligraphy* (artistic writing), which became an important Islamic art, also developed to serve in the learning of the Quran. Muslims often hang on their walls Quranic verses written out in beautiful decorative lettering.

It was the Quran that made Arabic an international language. It was adopted by Middle Eastern and North African countries in place of their original native tongues. As a result, Arabic is not only the language of the Quran, but of the whole Muslim ritual throughout the world (see **Islam**).

The Quran plays an important part in the daily life of all Muslims. The first chapter of the book, which begins as a hymn of praise for the one true God and an appeal for his guidance and blessing, is an essential part of the ritual daily prayers in Islam. Muslims have to memorize it, and it is read in Arabic many times a day throughout the Muslim world. Muslims everywhere must learn and read at least part of the Quran in Arabic. This is so that they can recite the holy speech which was spoken by the Prophet and his companions.

Many verses or expressions in the Quran are used in the daily lives of all Muslims. They include expressions such as "There is no god but Allah," "Muhammad is the Messenger of Allah," "Thanks be to Allah," "In the name of Allah," "By the will of Allah," "We belong to Allah and to Him we shall return."

Muslim children start to learn portions of the Quran by heart early in their education. The tradition of learning the entire Quran by heart started during Muhammad's lifetime and continues to the present day. It is a requirement for students of certain religious schools in Arab countries. A person who knows the Quran by heart is called a *hafiz*.

The art of reciting the Quran has become a profession for some people. These professional reciters gain great fame, distinction, and international repute in the Muslim world, rather like popular musicians in some Western countries. Recitations are now available on sets of cassette tapes, either in Arabic alone or with European translations. Muslims often give these tapes to each other as presents. The Quran is recited several times a day on the radio and television in many Arab countries. Some Arab countries set aside several hours a day on a special broadcasting channel exclusively for the reciting of the Quran.

When the Quran is recited, Muslims are required to listen to it attentively. They swear by the Quran for solemn oaths, not just in law courts but also on other occasions in normal daily life.

Since Muslims believe that the Arabic text of the Quran is the true Word of God, they consider translations to be no more than renderings of the meaning of the Quran. There are many English translations of the Quran. Existing English translations of the Quran have all been the work of individuals. No native Arab who is a scholar of the Quran has participated in them. Arabs find that these translations do not begin to capture the mood or effect of the Arabic Quran. But most accept the need for them in allowing non-Arabs to understand the holiest book of Islam.

See also **Islam; Muhammad; Ramadan.**

Qwaqwa was one of ten *homelands* (nation states) set up by the South African government under the former policy of *apartheid* (enforced racial separation). It was home to more than 180,000 people who speak South Sotho as their first language. The homelands were reincorporated into South Africa on April 27, 1994. Qwaqwa means "whiter than white" in the San language. The name describes the sandstone hills that surround the former homeland.

Qwaqwa covered about 500 square kilometres. It was located in the northeastern part of the Orange Free State, near the Lesotho border. The capital was Phuthaditjhaba. The area is the main producer of asparagus in southern Africa. Other crops include maize, potatoes, sorghum, vegetables, and wheat.

By the early 1990's, about 57,000 adult Qwaqwa citizens were registered as migrant labourers in other parts of South Africa. A further 2,000 people commuted to work in South Africa each day. After 1994, people living in the area once covered by Qwaqwa still suffered some of the damaging effects of the government's former homelands policy. These included unemployment and a shortage of adequate housing, food, medical care, and schools.

See also **Apartheid; South Africa, History of.**

Rr

R is the 18th letter of the English alphabet. It was also a letter in the alphabet used by the Semites who once lived in Syria and Palestine. They named it *resh,* their word for *head,* and adapted an Egyptian *hieroglyphic,* or picture symbol, for a human head to represent it. The Greeks later called the letter *rho.* When the Romans adopted it, they gave it its present capital *R* form. See **Alphabet**.

Uses. *R* or *r* is about the sixth most frequently used letter in books, newspapers, and other printed material in English. *R* is used to stand for *Respond* or *Response* in prayer books and liturgies. *R* indicates *radius* in mathematics; *radical* in chemistry; and *resistance* in electricity. R is the international car registration for Romania. In titles, *R* may mean *royal* as in *RN,* for *Royal Navy,* or *registered* as *Registered Nurse.* In some countries, *r* is known as the abbreviation for a unit of money, for *rouble* in Russia and for *rupee* in India. It is an abbreviation for *rook* in chess.

Pronunciation. The most common way to produce an *r* is to place the tip of the tongue close to the upper gum with the sides of the tongue just touching the upper back teeth. The breath escapes between the tongue and gum. In a rolled or trilled *r,* the tongue is held loose and the breath causes the tip of it to vibrate rapidly against the gum. The vocal cords usually vibrate to produce an *r.* In some English dialects, *r* is silent in such words as *farm* and *fort.* See **Pronunciation.**

Development of the letter R

The ancient Egyptians, about 3000 B.C., wrote a symbol of a human head.

The Semites adapted the Egyptian symbol about 1500 B.C. They called the letter *resh,* their word for *head.*

The Phoenicians, about 1000 B.C., changed the Semitic symbol and made it a triangle with a tail.

P

The Greeks used a P-shaped letter about 600 B.C. They called it *rho.*

R

The Romans gave the R its capital form about A.D. 114.

The small letter r developed during the A.D. 200's from Roman writing. Monks who copied manuscripts shaped the letter. By the 1500's, it had the form we use today.

A.D. 200 | 1500 | Today

Special ways of expressing the letter R

R

International Flag Code

International Morse Code

Braille

American Sign Language | British Sign Language

Semaphore Code

Common forms of the letter R

Rr *Rr*

Handwritten letters vary from person to person. *Manuscript* (printed) letters, *left,* have simple curves and straight lines. Cursive letters, *right,* have flowing lines.

Rr *Rr*

Roman letters have small finishing strokes called *serifs* that extend from the main strokes. The type face shown above is Baskerville. The italic form appears on the right.

Rr *Rr*

Sans-serif letters are also called *gothic letters.* They have no serifs. The type face shown above is called Futura. The italic form of Futura appears on the right.

R

Computer letters have special shapes. Computers can "read" these letters either optically or by means of the magnetic ink with which the letters may be printed.

℞ is a symbol used on prescriptions written by doctors. It is generally accepted as representing the Latin word *recipe,* which means *take.* ℞ is traceable to ♃, the sign of Jupiter, which was placed on ancient prescriptions to appeal to that god for favourable action of the medicine. A more recent explanation of the cross at the end of the R, is that it is merely a substitute for a full stop.

Rabat (pop. 518,616) is the capital of Morocco. Rabat is in the northern part of the country. It lies on the Atlantic coast at the mouth of the Bou Regreg, a shallow river (see **Morocco** [map]). The Bou Regreg separates Rabat from Salé, a city of about 290,000 people.

Rabat is divided into old and new sections. The old section, called the *medina,* is in the northern part of the city. It has small, white, flat-roofed houses and several *mosques* (Muslim houses of worship). The new section spreads out around the medina. It has broad streets and modern European-style buildings. The royal palace is located in this part of Rabat. The two sections of the city are connected by Avenue Muhammad V, the main business street. Hassan Tower, the *minaret* (prayer tower) of an incomplete mosque, stands on a bluff overlooking the Bou Regreg. Nearby is the tomb of Muhammad V, the first ruler of independent Morocco.

Rabat is chiefly a government and administrative centre. It has textile and cork-processing industries. It also produces asbestos products, bricks, cement, and flour. Craftworkers in the city make baskets, carpets, leather goods, tapestries, and other handicrafts.

Muhammad V University was founded in Rabat in 1957. Rabat's Archaeological Museum exhibits objects from prehistoric and Roman times.

The Romans occupied the site of present-day Rabat in the first century after Christ. Ruins of Roman buildings stand in southeastern Rabat. The Berber leader Abd-al-Mumin and his grandson Yakub al-Mansur established the present city in the 1100's. In 1912, France established a protectorate over most of Morocco. The French made Rabat their headquarters. When the protectorate ended in 1956, Rabat became the capital of the independent nation of Morocco.

Rabaul (pop. 14,937), on New Britain, is the busiest port in Papua New Guinea. It handles more copra and cocoa than any other port in the country.

Rabaul lies on Simpson Harbour, at the northern end of New Britain. It is surrounded by active volcanoes. Mount Kombiu, the largest, rises more than 600 metres above sea level. Rabaul has a fine natural harbour. Ships take on copra and cocoa from nearby plantations and the Bismarck Archipelago.

Rabaul was once the chief trading and administrative town in New Guinea. In 1937, two volcanoes erupted and destroyed much of the town and its port. During World War II (1939-1945), the Japanese army occupied Rabaul. Allied forces bombed the town many times. It was rebuilt after the war.

Rabbi is the title given to an ordained Jewish minister. The word is Hebrew and means *my master* or *my teacher.* The title of rabbi was popularized in the Mishnah, an important book of Jewish law compiled about A.D. 200. Many influential leaders of medieval Jewish communities were rabbis. They wrote books and helped people with their religious and worldly concerns, and they frequently represented Jewish communities to non-Jewish groups. They often served as judges in civil and religious legal cases. Some of the most famous rabbis were also doctors.

In recent times, the role of the rabbi has changed. Today, the main responsibilities of rabbis are to preach, counsel, officiate at religious services, teach, and conduct important personal and community celebrations. Some also serve as authorities on Jewish law.

Despite the importance of ordination to become a rabbi, no uniform course of study is required for all rabbis. Modern rabbi training schools, called seminaries or *yeshivot,* often teach the Bible, the Talmud, Jewish philosophy, and the history and literature of the Jews. Major schools in Europe and America also train future rabbis in teaching, preaching, and caring for the needs of their congregations. Individual rabbis may train and certify their students as rabbis.

See also **Judaism** (The rabbi).

Rabbit is a furry animal with long ears and a short, fluffy tail. Rabbits do not walk or run, as most other four-legged animals do. A rabbit moves about by hopping on its hind legs, which are much longer and stronger than its front legs. The animal also uses its front legs when it moves. Rabbits balance on their front legs much as people balance on their hands when they play leapfrog. When chased by an enemy, a rabbit can hop as fast as 30 kilometres an hour. Many children have pet rabbits. Pet shops sell tame rabbits that have been raised to be pets.

Rabbits live in Africa, Asia, Europe, North America, and have been introduced to other parts of the world. Most species make their homes in fields and prairies where they can hide their young under bushes or among tall grasses. A female rabbit usually has four or five young at a time, and may give birth several times every year.

A young cottontail rabbit sits motionless to escape hunters, but hops away quickly if they come near.

For thousands of years, people have hunted rabbits for meat and for skins. Today, most rabbits used for food and fur are raised by people, but shooting enthusiasts still hunt wild rabbits. Many people enjoy rabbit meat, which is sold fresh or frozen. Rabbit skins are used for making fur coats, or as trimming for cloth coats and hats. The skins can be cut and dyed to look like mink, beaver, or some other more valuable fur. A stiff cloth called *felt* may be made by squeezing rabbit fur together with other kinds of fur.

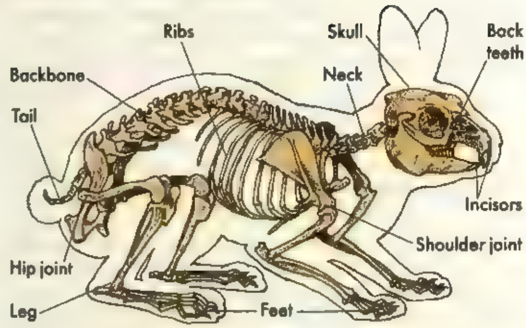
Rabbits and hares look much alike, and are often mistaken for each other. Some are even misnamed. For example, the Belgian hare is a rabbit, and the jack rabbit is a hare. Most rabbits are smaller than hares and have shorter ears. The animals can be told apart most easily at birth. A newborn rabbit is blind, it has no fur, and it cannot move about. A newborn hare can see, it has a coat of fine fur, and it can hop a few hours after birth. In addition, the bones in a rabbit's skull have a different size and shape from those in a hare's skull.

The body of a rabbit

Wild rabbits have soft, thick brownish or greyish fur. The fur of pet rabbits may be black, brown, grey, white, or combinations of these colours. An adult wild rabbit grows up to 20 to 35 centimetres long and weighs 0.9 to 2.3 kilograms. Pet rabbits may grow about 20 centimetres longer and weigh 2.3 kilograms more. Most females are larger than males. Few rabbits live more than a year in the wild because they have little protection against enemies. Pet rabbits live as long as five years.

A rabbit's eyes are on the sides of its head. As a result, the animal can see things behind or to the side better than in front. Rabbits can move their long ears together or one at a time to catch even faint sounds from any direction. Rabbits also depend on their keen sense of smell to alert them to danger. A rabbit seems to twitch its nose almost all the time.

The skeleton of a rabbit



Rabbit tracks in snow

Rabbits were once classified as *rodents* (gnawing animals). Like beavers, mice, and other rodents, rabbits have chisel-like front teeth for gnawing. But unlike rodents, rabbits have a pair of small teeth behind the upper front teeth.

A rabbit's tail is about 5 centimetres long, and is covered with soft, fluffy fur that makes it look round. The fur on the underside of the tail of most kinds of rabbits has a lighter colour than that on top.

Two rabbits sniff each other in greeting. Rabbits have a keen sense of smell, sight, and hearing.

Rabbits have scent glands in the groin, near the anus and sex organs, and under the chin. Secretions from these glands are used to mark territory, and as a form of sexual attraction.

Kinds of rabbits

The best known kinds of rabbits are the *European rabbit,* and various species of *cottontail rabbits* of North, Central and South America. *Domestic rabbits* are tame breeds of the European rabbit.

The European rabbit is native to Spain and Portugal but was introduced to the rest of Europe by the Romans about 2000 years ago. It is a sociable animal that lives in burrows. The whole burrow system is known as a *warren.* The Romans reared rabbits for food in walled enclosures called *leporaria.* Later, in the Middle Ages, rabbits were reared in monastries. Today, rabbits are found in most habitats from sand dunes and grassland, to open hillsides, and even deserts.

Young rabbits are born at the end of a special breeding burrow or *stop,* set aside from the main warren. The female makes a nest of fur that she plucks from her chest. She feeds the young for only a short period each day. Rabbit milk is rich in proteins and fats. After feeding her young, the female rabbit stops up the burrow entrance with earth and grass to disguise it from predators. When feeding on grass above ground, a female rabbit may be accompanied by a particular male, although she will mate with more than one male when she is *on heat* (receptive to mating). In Northern Europe, the rabbit produces 3 to 5 litters each year, of 5 to 6 young. Rabbits cause damage by eating grasses, herbs, cultivated plants, and the bark of shrubs and trees. They are particularly destructive to pasture land as they kill grass by feeding on the roots as well as the leaves.

Rabbits were first taken to Australia in the late 1700's. In the late 1800's the rabbit became a serious pest, spreading right across the southern half of the continent. Most efforts to control the spread of rabbits in Australia failed, including the erection of thousands of miles of rabbit-proof fencing. The only success was the introduction of the rabbit disease *myxomatosis* which killed millions of rabbits in the 1950's. Since that time the rabbit has become immune to the disease and their numbers have increased again.

Cottontail rabbits are named after the white or light grey fur on the underside of their tails which looks like a ball of cotton. Most cottontail species live in burrows made by other animals. Only the *pygmy cottontail* of the northwestern United States digs its own burrow. Cottontail rabbits are not sociable animals like the European rabbit. They give birth to their young in a fur-lined nest above ground. Cottontails are found mainly in scrubby areas and deserts. One species, the *marsh rabbit* of the southeastern United States lives in marshes and swamps and can swim well.

Other kinds of wild rabbit include the *volcano rabbit* that lives only in two upland areas of open pine forest near Mexico City. This is the smallest rabbit species, up to 35 centimetres long. It has a dark brown coat, dark brown above, reddish below. The *bunyoro rabbit* has a coat of stiff yellow brown hairs. This species has small ears and is widely distributed in Central Africa.

Domestic rabbits are raised for their meat and fur, for use in scientific research, and as pets. People throughout the world raise rabbits for their tasty, nutritious meat. Commercial rabbit breeders market thousands of kilograms of rabbit meat yearly.

Artificial furs have largely replaced rabbit fur in clothing. However, the Angora rabbit is still raised for its long fur, which is spun into a soft, warm yarn. Rabbit fur is also used to line caps and gloves, to trim coats, and in making plush toys.

The use of rabbits in research laboratories requires great numbers of highly similar animals, which only large commercial breeders can provide.

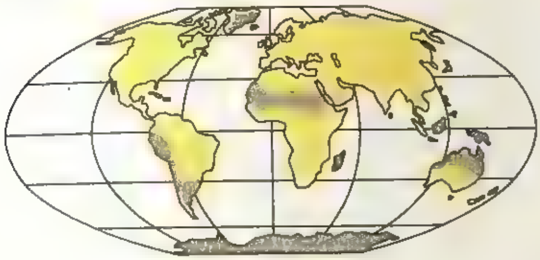
Certain breeds of domestic rabbits are raised for show, and others make good pets. Popular show breeds include the Belgian hare, Dutch, Rex, and White Flemish Giant. The White Flemish Giant weighs up 8 kilograms and is the largest breed of rabbit. Judges rate rabbits on such features as size and shape, and the quality and colour of the fur. Favourite pet breeds include the Dutch and Netherland Dwarf.

An angora rabbit is raised for its fur. The long white hairs are plucked from the animal's coat and spun into soft yarn.

Belgian hares are raised for show. The Belgian hare is not really a hare but is a breed of European rabbit.

Where rabbits live

The yellow areas in the map, *below,* show where rabbits are found.



Pet rabbits

Many rabbits are raised to be pets. Few wild rabbits live long in captivity. Most rabbits do not like to be held or petted too often. Never lift a rabbit by its ears or legs. Grasp the loose skin over the animal's shoulders with one hand, and place the other hand under the rump to support the rabbit's weight.

Cage. You can buy a *hutch* (rabbit cage) at a pet store, or you can build one. Place the hutch outdoors in a shady place. It should stand on a platform about 90 centimetres off the ground so it will not be flooded. The platform also keeps the rabbit from trying to dig burrows under the hutch. A rabbit needs plenty of fresh air, but must be kept warm and dry. In winter, the hutch should be put in a well-lit basement or in a sun-warmed shed to protect the animal from the cold. The hutch must be cleaned thoroughly every day. Fresh hay should be put in the rabbit's sleeping box at least twice each week.

Food. Pet rabbits eat such whole grains as barley, oats, and wheat. You can also give your pet beets, carrots, turnips, fresh-cut clover, or grass. You can give the animal some hay at night. Hay helps the rabbit's digestion, and biting the hard stalks helps wear down the front teeth, which grow continuously. If you feed the rabbit cabbage, give it only small amounts or it may become ill. Keep a bowl of fresh water in the hutch.

Do not overfeed your rabbit. All green foods should be removed as soon as the rabbit has finished eating because they spoil quickly. Some grain can be left in the trough at night.

Scientific classification. Rabbits belong to the family Leporidae. The European rabbit is *Oryctolagus cuniculus.* Cottontail rabbits are genus *Sylvilagus.* The Pygmy rabbit is *S. idahoensis,* the marsh rabbit is *S. palustris,* the volcano rabbit is *Romerolagus diazi,* the Amami rabbit is *Pentalagus furnessi,* and the Bunyoro rabbit is *Poelagus majorita.*

See also **Fur** (table); **Hare; Jack rabbit; Myxomatosis.**

Rabbit fever. See **Tularemia.**

Rabelais, François (1494?-1553?), a French humanist, wrote the comic narrative *Gargantua and Pantagruel.* Gargantua and his son Pantagruel are giants with enormous appetites. In the work, Rabelais used laughter to question and examine the most important institutions of his time. For example, the comic descriptions of Gargantua's education really satirize the educational methods of the time and express Rabelais' own ideas on the subject. Although famous for the earthy quality of his humour, Rabelais wrote earnestly about many subjects.

Rabelais was born near Chinon in the province of Touraine. He became a Franciscan monk in 1520, and received a bachelor of medicine degree in 1530 from the University of Montpellier. He practised and lectured on medicine from 1532 to 1546.

In 1532, Rabelais published *Pantagruel,* a continuation of an anonymous popular work, *Chronicles of the Giant Gargantua* (1532). While preserving its popular tone, Rabelais added much learned material, and showed extraordinary gifts as a satirist and storyteller. *Pantagruel* was condemned for obscenity by the Sorbonne, the theological college of the University of Paris. In 1534, Rabelais published *Gargantua,* his own version of the episodes preceding *Pantagruel.* This book, which introduces the mischievous monk Frère Jean, was also condemned by the Sorbonne. In 1546, Rabelais published Book Three, which the Sorbonne condemned for heresy. He published Book Four in two parts, in 1548 and 1552. Rabelais may have written only parts of Book Five. This work appeared in 1562 and 1564, after his death.

With his linguistic creativity, Rabelais invented many words, some of which remain in the French language. His verve, his optimism, his delightful storytelling, and his ability to become involved in both humour and ideas, have made him one of the greatest and most loved French writers.

See also **French literature** (The Renaissance); **Humanism.**

Rabies is an infectious disease that destroys the nerve cells of part of the brain and almost always causes death. Human beings and all other warm-blooded animals can get the disease. The word *rabies* is Latin for *rage* or *fury.* The disease probably received its name because infected animals often become frenzied and attack any object or animal in their way. Because one of the symptoms of rabies is an inability to swallow water, the disease is sometimes called *hydrophobia,* which means *fear of water.*

Cause. Rabies is caused by a virus known as a *rhabdovirus.* Most mammals can carry this virus, which usually lives in the nerve cells and glands of the *host* (carrier). The rabies virus can be carried in the salivary glands for long periods of time. If the host bites another animal or a human being, or if some of its infected saliva enters an open wound, the victim may get rabies. Dogs, cats, and wild animals are common sources of infection for people. Research indicates that the rabies virus can also enter mucous membranes, such as those lining the nose and eyes. People and other mammals can develop rabies after breathing the air in caves that house large numbers of bats, which may carry the virus.

When rabies virus enters the body, it travels along nerves to the spinal cord and up to the brain, producing inflammation. Symptoms of the disease generally develop about 10 days to 7 months after exposure.

Symptoms in human beings. Among the first symptoms are pain, burning, or numbness at the site of the infection. The victim complains of headaches and is extremely restless. Muscle spasms make the throat feel full, and swallowing becomes difficult. Later, the patient may have convulsions. After a day or two, a quiet period

can occur, which can progress to unconsciousness and, finally, death. Symptoms of the disease generally last from 2 to 12 days.

Symptoms in animals. The development of rabies in animals follows the same pattern as in people. During the period of excitation, the animal may wander great distances. It vocalizes almost constantly, often becomes aggressive, and will attack without reason. The disease then usually progresses to paralysis of the jaw and throat muscles, followed by general paralysis and death. Some animals with rabies never show signs of excitation but only of paralysis. Some animals that recover from rabies continue to carry and spread the virus for a time.

Treatment. The first step in treating a person bitten by any animal should be to wash the wound with soap and water. The animal should either be caged and watched for signs of rabies, or killed and its brain tissue tested for rabies virus. If either procedure indicates the presence of rabies, a doctor should begin preventive treatment. Preventive treatment consists of one injection of antirabies globulin followed by five injections of rabies vaccine. Vaccinating all dogs and cats against rabies is an important means of controlling the disease.

See also **Pasteur, Louis.**

Rabin, Yitzhak (1922-), became prime minister of Israel in 1992. He had previously held office as prime minister from 1974 to 1977.

Rabin was born in Jerusalem and was the nation's first prime minister to have been born in Israel. Israel's previous prime ministers were born in Europe. In 1941, during World War II, Rabin joined the *Palmach,* a unit of the Jewish underground army in Palestine. He was deputy commander of the Palmach in 1948 during the first Arab-Israeli war. Rabin headed Israel's defence forces from 1964 to 1967. He planned the strategy in the Six-Day War of June 1967, in which the Israelis defeated the Arabs and occupied the Arab lands of the Gaza Strip and West Bank.

From 1968 to 1973, Rabin served as ambassador to the United States. A member of the Labour Party, he was elected to Israel's parliament in 1973. He served briefly in the Cabinet as minister of labour. He became Labour Party head and prime minister in 1974, and held those posts until 1977. He was minister of defence from 1984 to 1990.

Rabin again became Labour Party leader in February 1992. Elections held in June brought the party to power, and Rabin became prime minister again. Rabin appointed himself minister of defence. In 1993, Rabin's government and the Palestine Liberation Organization (PLO) signed an agreement that included the start of a plan for self-government for, and Israel's withdrawal from, the Gaza Strip and the West Bank. In May 1994, Israel withdrew from the Gaza Strip and the West Bank city of Jericho. Palestinians began administering these areas. Israel and the PLO also recognized each other and agreed to try to work out their long-standing conflicts. In July 1994, Rabin and King Hussein I of Jordan signed a declaration that ended a state of war that had technically existed between Israel and Jordan since 1948. Rabin was awarded the 1994 Nobel Peace Prize jointly with PLO leader Yasir Arafat and Israeli foreign minister Shimon Peres.

Yitzhak Rabin

Rabinowitz, Solomon. See **Sholom Aleichem.**

Raccoon is a furry animal that has a bushy, ringed tail and a band of black hair around its eyes. This black hair looks like a mask. Raccoons belong to the same family as coatis, kinkajous, and ringtails.

There are six species of raccoons, all native to the New World. The two main species are the common raccoon and the crab-eating raccoon. The common raccoon lives in Canada, the United States, and Central America. The crab-eating raccoon lives in Costa Rica, Panama, and South America. Several kinds of raccoons live on tropical islands.

The body of a raccoon. The common raccoon measures from 60 to 110 centimetres long, including its tail. Most raccoons weigh from 3.5 to 8 kilograms, though some males may weigh more than 18 kilograms. Males are usually about 25 per cent larger than females.

A raccoon has coarse, long hair that is generally grey in colour, but sometimes tinged with yellow or brown, with pale brown or grey underfur.

The tail of both the common and the crab-eating raccoon may grow as long as 38 centimetres. Most raccoon tails have from five to seven rings. Both main species have a pointed snout and long, flexible fingers. Raccoons have strong, sharp claws, which help them climb.

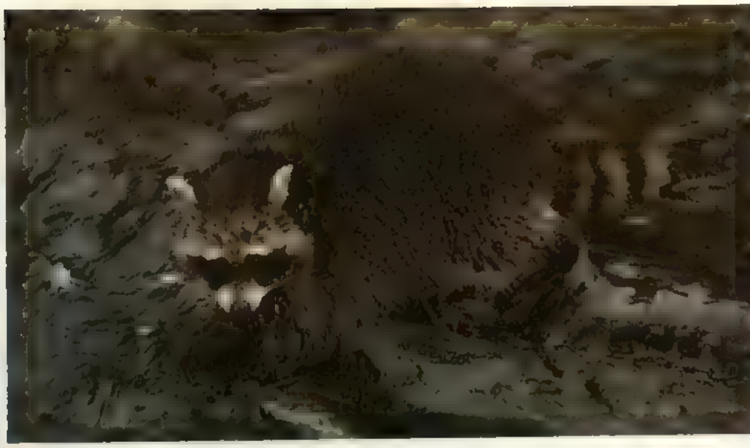
The life of a raccoon. Raccoons live both on the ground and in trees. They live alone or in small family groups. Each raccoon has a *home range.* Most raccoons in good *habitats* (living areas) have home ranges of about 40 to 100 hectares. Adult males may roam up to 16 kilometres in some habitats. Raccoons usually hunt for food at night and stay in their dens during the day. They walk like bears, with all four feet flat on the ground, and are good swimmers. Raccoons in captivity may live 15 years. In the wild, they probably live fewer than 5 years.

Raccoons that live in wooded areas have their den in a hollow log, stump, or tree. They may also make their home in an abandoned barn or farmhouse. In treeless areas, raccoons may make their nest in high grass.

Both common and crab-eating raccoons eat crabs. Their other food includes crayfish, frogs, fish, and other freshwater animals. Raccoons also eat acorns, birds' eggs, maize, fruit, nuts, seeds, and small rodents. In urban areas, they raid dustbins.

Common raccoons mate once a year in January or February. About nine weeks after mating, the female has from one to eight babies. Newborn raccoons have no mask around their eyes or rings on their tail. Their eyes open about 20 days after birth. The mother carefully protects her young and does not even let the father near them. The babies stay in the den for 8 to 10 weeks. Then they begin to follow their mother when she searches for food. They may stay with her for up to a year.

People and raccoons. The American Indians hunted raccoons for their furs. After the arrival of Dutch, English, and French fur traders, the Indians exchanged pelts for guns and other items. The American colonists made raccoon pelts into caps, overcoats, and sleigh robes.



A raccoon has a "mask" of black hair around its eyes. This furry mammal eats fish and frogs that it catches in rivers and streams.

The feet of a raccoon

Raccoon tracks

They also used raccoon furs as a kind of money before paper currency was established.

Raccoon hunts are a favourite sport in some rural areas of North America. People use dogs to chase the animals until the raccoons jump up into trees to escape.

Some people keep raccoons as pets. Raccoons are more intelligent than cats and can be easily trained. But after they reach the age of about 1 year, they may be easily angered and, as a result, often bite and scratch.

Raccoons can be a serious nuisance if they break into hen houses and kill poultry. They also damage corn crops by breaking the stalks of the plant and eating the growing corn.

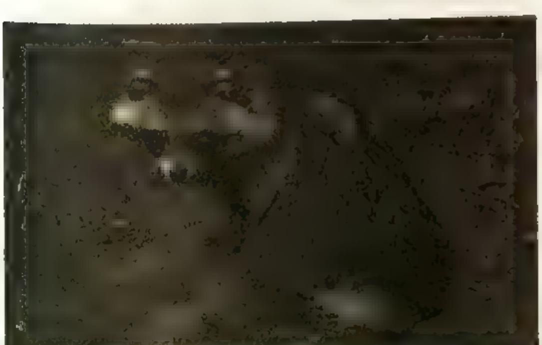
Scientific classification. Raccoons belong to the raccoon family, Procyonidae. The common raccoon is *Procyon lotor.* The crab-eating raccoon is *P. cancrivorous.*

See also **Coati; Fur; Kinkajou; Panda; Ringtail.**

Raccoon dog is a member of the dog family that has thick fur with markings similar to a raccoon. The original home of the raccoon dog is the forests of Siberia and Eastern Asia, including Japan. Between the 1920's and 1950's the racoon dog was introduced to the western part of the Soviet Union for its fur. Since then it has spread through Scandinavia and Western Europe.

The raccoon dog is about 80 centimetres long including a bushy tail that can be held above the body like that of a dog. It is mainly *nocturnal* (active at night). Its diet includes animals and plants varying from rodents and reptiles to insects, seeds, and berries. Raccoon dogs live in pairs and the male helps rear the pups.

Scientific classification. The raccoon dog belongs to the dog family, Canidae. It is *Nyctereutes procyonoides.*



The raccoon dog is a small foxlike animal that lives throughout eastern Asia. The animal has a chunky body, a greyish fur coat, and a masked face that makes it look like a raccoon.

Race relations laws protect people from being discriminated against on grounds of race. In some countries, such laws are known as racial discrimination laws. These laws protect against being refused a job or accommodation because of race. The laws may also be designed to help immigrants or other minority groups know each other better.

In the United Kingdom, the Race Relations Act of 1965 made illegal some aspects of racial discrimination. The Act set up the Race Relations Board, which investigated complaints of discrimination. The Race Relations Act of 1968 set up the Community Relations Commission, which worked to develop good relations between the main population and immigrant groups. The Race Relations Act of 1976 set up the *Commission for Racial Equality.* The Commission can take to court people who have broken laws against discrimination. The Commission seeks to promote good relations among the various racial groups living in Britain.

In Australia, the Commonwealth Parliament passed the Racial Discrimination Act in 1975 which set up a Commission for Community Relations. The provisions of the act are not as strong as the laws in the United Kingdom.

Many other countries have laws against racial or religious discrimination, or promoting good relations between various cultural groups.

Raceme is a type of flower cluster. A raceme has a single central stem that bears several flowers, each on a stalk, in a spiral arrangement. The central stem is called the *peduncle.* The stalk bearing each flower is called a *pedicel.* Each flower bud of a raceme forms above a small modified leaf called a *bract.* The flowers of a raceme develop in a spiral pattern, with the lowest flowers on the peduncle developing first. Flowers continue to develop at the tip of the peduncle as it grows. This type of flowering is called an *indeterminate inflorescence* (see **Inflorescence**). The hyacinth and the lily-of-the-valley produce flowers in racemes.

Human beings resemble one another in many essential ways. However, people also differ from one another. The youngsters in this photo exhibit variations in skin colour and hair colour. Today, most experts avoid classifying people into races based on such variable physical characteristics.

Human races

Races, Human. All human beings are descended from people who lived hundreds of thousands of years ago. Therefore, we all share a common ancestry. This means that all people living in the world today are related to one another. But even though we are all related, we do not all look alike. Our bodies have different sizes and shapes, our skins have varying shades, our eyes differ in colour and shape, our lips and noses have different shapes, and our hair has different colours and textures.

Most anthropologists believe that human beings originated in Africa and gradually spread throughout the world (see **Prehistoric people** [How prehistoric human beings developed]). They have observed that groups of people who have lived in certain parts of the world for many thousands of years tend to differ from groups living in other parts of the world. Living in regions with differing environments is one reason human beings have developed different appearances. For example, people whose ancestors lived for many generations in northern parts of the world—such as northern Europe or northern Japan—tend to have light-coloured skin. People who come from places near the equator, such as central Africa or southern India, tend to have dark-coloured skin. People who come from places between those two environmental extremes tend to have medium-coloured skin. For information on how skin colours result from adaptations to the environment, see the *Climatic adaptations* section of this article.

In some instances, we observe that certain physical traits tend to cluster in a group. For example, we might associate blond hair, blue eyes, and fair skin with people from Denmark, Norway, and Sweden. We also might associate red hair, green eyes, and a freckled complexion with people from Ireland. However, many people in these four countries actually have brown hair, brown eyes, and light brown skin. This example shows some of the problems facing human biologists who attempt to classify human beings into races.

Biologists define a race as a subdivision of a plant or animal *species*. The members of the same species resemble one another in many essential ways. Most importantly, they can breed with one another and produce fertile offspring. Members of different species usually cannot interbreed and produce fertile offspring. Grizzly bears and black bears, for example, are closely related North American bears. Despite their similarities, grizzly bears and black bears do not interbreed. Therefore, they belong to different species.

Many plant and animal species can be subdivided into groups that differ from one another. These groups have been called *races, subspecies, natural populations, breeds,* or *varieties.* Among grizzly bears, for instance, biologists observe distinct physical differences from re-

gion to region. They group grizzly bears into subspecies based on these differences.

All living human beings belong to the subspecies *Homo sapiens sapiens.* But like those of the grizzly bear, human populations differ from one region to another. Scholars have used these differences to classify people into various races. They have devised racial categories for human beings according to such physical characteristics as the colour of the skin, the colour and texture of the hair, and the shape of the eyes.

But some people assigned to the same race—and even some members of the same family—have widely differing features. Over the years, scientists have disagreed over how many races of human beings can be devised, and over which individuals belong to what race. For this reason, many anthropologists and biologists have come to believe that the assignment of a racial label to any group of people is arbitrary and thus open to argument.

For many years, most scholars believed that "pure" races of human beings existed some time in the prehistoric past. According to these scholars, the "pure" human races developed in complete isolation from one another, and the members of each race exhibited physical characteristics that the members of other races did not possess.

Today, however, most *physical anthropologists* (scientists who study the physical differences and prehistoric development of human beings) doubt that "pure" races ever existed. They point out that people have probably always taken mates from outside their own population as well as from within. They also note that as transportation and communication have become easier, populations have blended more and more. For these reasons, the biological definition of race does not describe human populations well. Most anthropologists now avoid classifying people into races. Instead, they try to learn more about human diversity by studying how human traits vary throughout the world.

Despite the lack of a scientifically valid racial classification system, people generally consider those who "look different" from themselves to be members of a different race. As a result, the concept of race remains important in a sociological sense. Societies continue to divide their members into "races"—though the criteria and labels used may vary from society to society.

The idea of race has often been misunderstood, and the term has sometimes been misused on purpose. The biological concept of race has often been confused with culture, language, nationality, or religion. Differences in physical appearance have led some people to mistakenly conclude that members of different groups are born with differences in intelligence, talents, and moral standards. Race has also been a major basis of *discrimination*—that is, the treatment of other groups as inferior to one's own group. For more information, see the *World Book* articles on **Minority group, Racism,** and **Segregation.**

This article describes some racial classification systems that have been used over the years and discusses alternative approaches to the study of human variation. It also describes how the physical characteristics of human beings change, and it discusses the social significance of race.

Systems of racial classification

Physical differences among human beings have long been recognized, and many of these differences have been used throughout history as bases of racial classification. Obvious physical characteristics, such as size, build, skin colour, eye form, hair form, and nose shape, were the main criteria of early classifications of race, with skin colour considered most important.

Since the beginning of recorded history, scholars have classified human beings in different ways, and the number of categories recognized by each system varied. The development of racial classification systems was influenced by three important theories: (1) the three-race theory, (2) evolutionary theory, and (3) the geographical-race theory.

The three-race theory. Ancient Egyptians, Greeks, and Romans knew about dark-skinned, curly-haired peoples that lived in Africa. They also knew about the so-called "yellowish-skinned" peoples of Asia, most of whom had folds of skin that extended from their eyelids over the inner corners of their eyes. Limited knowledge of the peoples of the world at this time suggested the existence of three races—European, or "white"; African, or "black"; and Asian, or "yellow." These groups eventually became known as Caucasoid, Negroid, and Mongoloid, respectively. For many years, scholars attempted to classify all human populations in terms of these three races, or some variation of the three. They believed that all people belonged to one of a limited number of racial types. They also believed that the traits of each race were fixed and unchanging.

The major period of European overseas exploration, which began in the late 1400's, provided increased contacts with peoples of different cultures. By the 1800's, it became evident that much of the world's population did not easily fit into the three-race system. For example, as Europeans came into contact with more and more Asian peoples, they realized that the skin of the people they had classified as Mongoloids was not really yellow, but that it varied from very dark to very light brown. They also discovered that the *epicanthic fold*—the inner eyefold thought to characterize Mongoloids—was rare in some Asian populations but present in some of the native peoples of southern Africa and North America. Lip form and hair form were also found to vary across the traditional racial groupings.

Evolutionary theory. The view that human beings could be classified into races based on fixed physical characteristics began to change dramatically as biologists came to accept the theory of evolution. During the early 1800's, most biologists believed that all plant and animal species remained the same from generation to generation. However, geologists found fossils of animals and plants that were not the same as living species, thus providing evidence that species were not fixed.

Even though scientists could now see that species could change, they did not know how evolution worked. It was the idea of *natural selection* as the mechanism for evolution that helped scientists understand how organisms could change over many generations. This idea, set forth by the British naturalist Charles R. Darwin in his book *The Origin of Species* (1859), states that populations of organisms can change over generations as they

The three-race theory

For many years, scholars classified all human populations into one of three races—Caucasoid, Negroid, or Mongoloid. The three illustrations below show the physical characteristics that were believed to typify the members of each race.

Typical Caucasoid traits were believed to include fair skin and fine, light-coloured hair, either straight or wavy. Blue eyes, a narrow nose, and fairly thin lips were also considered Caucasoid traits.

Typical Negroid traits were believed to include dark brown or black skin and coarse, kinky black hair. Brown eyes, a broad nose, and thick lips were also thought to characterize Negroids.

Typical Mongoloid traits were believed to include yellowish skin and coarse, straight black hair. A fold of skin across the inner corner of the eye was thought to characterize Mongoloids.

adapt to their physical environment. This new understanding of the processes of evolution through natural selection, when applied to human populations, showed that many of the supposedly "fixed" traits that had been used to identify races were actually adaptations that had evolved over time in response to environmental conditions. See **Evolution; Darwin, Charles R.**

Scientists saw that widely separated groups could develop similar characteristics as a result of adapting to similar environments, even if they shared no recent ancestral relationship. For example, the Quechua, a people who live in the Andes Mountains of South America, and the Sherpas, a people of the Himalaya in Asia, are only remotely related. However, they have many similar physical characteristics as a result of prolonged adaptation to living in their high mountain environments.

As they came to understand evolutionary theory, experts began to see the difficulty of trying to use adaptable traits to fit people into just a few major races. Physical anthropologists began to search for *nonadaptive,* or *neutral,* traits—that is, physical characteristics that would persist even if a population moved to a different environment. They viewed race as something fixed and unchanging and wanted to discover traits that were also unchanging. Anthropologists compared many traits and physiological processes of people living in different environments, including blood groups and rates of respiration, circulation, and metabolism. These comparisons are discussed later in this article, in the section on *How human populations develop and change.*

The geographical-race theory. In an effort to reconcile the theory of evolution with the observed variations among the world's populations, some anthropologists developed a new system of racial classification during the 1950's. They divided human beings into large categories called *geographical races.* These races were collections of populations that exhibited similar characteristics. One popular classification system recognized nine geographical races: (1) African, (2) American Indian, (3) Asian, (4) Australian, (5) European, (6) Indian, (7) Melanesian, (8) Micronesian, and (9) Polynesian.

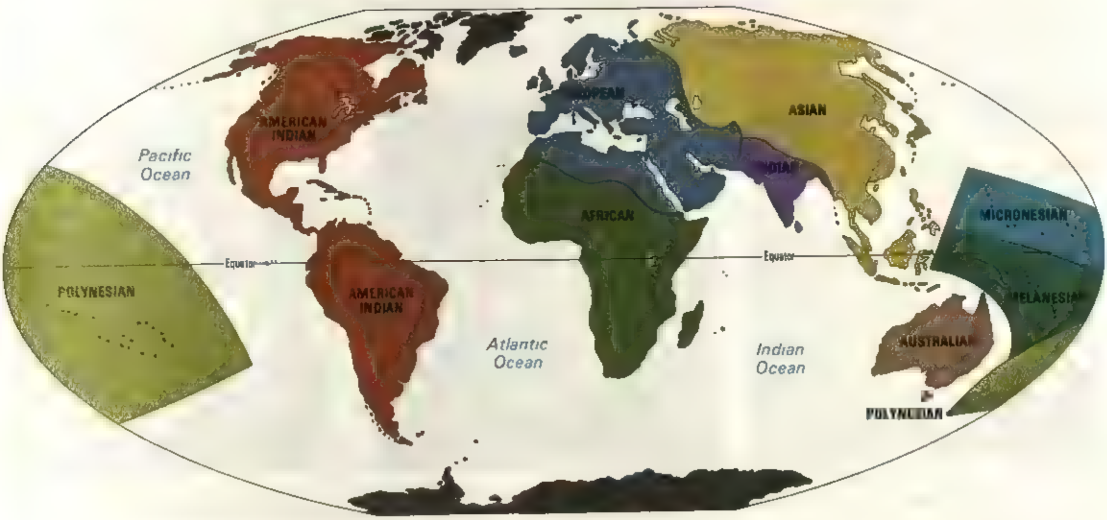
In general, the geographical races extended throughout major continental areas and large island chains. But they did not correspond exactly to the continents. For example, the European geographical race included populations throughout Europe, in the Middle East, and north of the Sahara in Africa. It also included descendants of these populations in other parts of the world, such as the "whites" of North America and Australia.

Geographical races were believed to exist because of the isolation caused by such natural barriers as oceans, mountains, and deserts. The idea was that these barriers separated groups of people for many thousands of years, allowing the populations to evolve in different directions. India, for example, is partly isolated from the rest of Asia by the Himalaya. According to the geographical-race theory, this isolation permitted the Indian geographical race to develop separately from the Asian geographical race.

Anthropologists used the term *local races* to describe distinct subcategories of geographical races. Some local races had millions of members. For example, the Northwest European local race included the populations of Scandinavia, Germany, Belgium, Luxembourg, the Neth-

The geographical-race theory

Geographical races were believed to exist because of the isolation created by oceans, mountains, and deserts. This map shows the races that were recognized by one popular classification system.



erlands, Great Britain, and Ireland. It also included peoples who emigrated—or whose ancestors emigrated—from those areas. Local races containing much smaller numbers of people included the Lapps of extreme northern Europe and the Basques, who live in the mountains between France and Spain.

Some anthropologists used the term *microraces* to describe the subpopulations that existed within local races. But microraces—and even local races—could not always be clearly defined. Within a given geographic area, the members of different subpopulations often intermarried, so the physical features used to define these groups blended together.

This expanded, detailed classification system represented a major change in the view of human races. The geographical-race system took into account the theory of evolution as well as heredity, recognizing that populations are shaped by their environment. However, many anthropologists believed it did not eliminate the problems of the older systems. Because members of different races could possess the same physical characteristics, the racial criteria could not be clearly identified.

Alternatives to racial classification

In the past, scholars based racial classifications on clusters of physical characteristics that supposedly represented the "typical" member of that race. But many of the individuals categorized in a particular race did not reflect all the characteristics attributed to that race. In addition, the scholars who constructed classification systems did not always agree on which traits—or how many—should be considered.

To see the problems involved in defining races by means of "typical" characteristics, consider skin colour. A pigment called *melanin* determines skin colour. Dark skin contains more melanin than light skin does. Skin colour has been used as a major classifying characteristic in all racial systems. For example, a light brown skin colour was considered "typical" for the members of the European geographical race. But some members of the race had skin that was far lighter than the "typical" colour, and others had skin that was much darker. Similarly, the members of the African geographical race "typically" had brownish-black skin. But again, many individuals classified in this race had skin that was lighter than the "typical" shade, and many others had skin that was darker.

To further confuse matters, some of the darker-skinned members of the European geographical race had skin as dark as some of the lighter-skinned members of the African geographical race. In view of these complications, it has become extremely difficult to assign people to a race based solely on skin colour.

Increasing the number of identifying traits only added more problems. The shape and fullness of the lips, for example, varied widely among people who were considered members of the same race. Furthermore, lip shape demonstrated the same kind of overlap among members of supposedly different races as did skin colour.

These problems have led many anthropologists to conclude that classification based on physical characteristics is not scientifically valid and serves no useful purpose. They find the study of human variation to be more productive than the assignment of racial labels. As a result, they have adopted alternate approaches to traditional systems of racial classification. Chief among these alternatives are (1) the clinal approach and (2) the population approach.

The clinal approach. The geographical distribution of a physical characteristic can be shown on a map by zones called *clines*. Clines are formed by drawing lines to connect points of the same or similar frequency. For example, in the case of skin colour, each cline includes locations at which populations demonstrate the same average skin colour. As variations from dark to light are plotted on a map, certain distribution patterns begin to emerge. A clinal distribution does not associate specific

The problem of skin colour in racial classification

According to the geographical-race theory, the individuals in the top row of photos would belong to the European race. The individuals in the bottom row would belong to the African race. But skin colour varies widely within each racial group. In addition, the skin of the Kuwaiti man—who would be assigned to the European geographical race—is about the same colour as that of the woman from southern Chad, who would be assigned to the African geographical race.

Woman from Norway

Woman from Germany

Man from Kuwait

Woman from southern Chad

Woman from Kenya

Woman from Togo

traits with traditional racial categories, nor does it associate different traits with one another. For example, skin colour and blood type would be plotted on separate maps and show different patterns of distribution.

The clinal approach has been used extensively to examine the worldwide distribution of blood types. Scientists classify human blood into groups according to proteins on the membranes of the red blood cells. The presence or absence of these proteins is determined by heredity. Studies show differences in the frequencies of some blood groups throughout the world.

The best-known blood-group system is called the ABO system. In this blood-group system, type O is the most common. Type O is followed by types A, B, and AB. Other systems that are used in comparing blood-group frequencies include the Kell, Kidd, Lutheran, MNS, P, and Rh systems. See **Blood** (Blood groups).

Clines of blood-type distribution help anthropologists consider possible explanations for the geographic variations they observe. For instance, clinal mapping shows that central Asia has the lowest frequencies of type O blood. One possible explanation for this has to do with the deadly epidemic disease bubonic plague—a disease that has long been present in central Asia. The surface proteins that characterize type O red blood cells resemble the surface proteins found on the infectious bacteria that cause bubonic plague. Normally, the body can produce disease-fighting chemicals that recognize and attack cells that carry the bubonic-plague surface proteins. But if a person has type O blood, the body is less likely to make these disease-fighting substances because they would damage its own red blood cells. During a plague epidemic, central Asians with type O blood would have been at greater risk of dying from the disease than were those with other blood types. Over the centuries, this disadvantage could have led to the comparatively low frequency of type O blood in central Asia.

The population approach is used to study patterns of variation among human populations. Anthropologists define a population as a group of similar people who

are more likely to mate with one another than with outsiders. Anthropologists using the population approach investigate clusters of physical traits but make no assumptions about race on the basis of those clusters. Instead, they see each population as the product of a unique set of circumstances, including adaptation, genetic change, isolation, and history of migration. These researchers then attempt to explain the similarities and differences among the populations. They do not try to fit the populations into racial categories.

The population approach assumes that groups of people who have lived in similar environments for a long period will demonstrate similar adaptations. This can happen even if the location of these similar environments is far apart. For example, populations living at very high altitudes must adjust to extreme conditions. Temperatures can get extremely hot during the day and very cold at night. Also, the air pressure is so low that less oxygen is available, making breathing more difficult. Throughout the world, populations living at high altitudes show specific traits in response to similar environmental conditions. For instance, their lungs can hold more air than those of people at lower altitudes, enabling them to inhale more oxygen with each breath.

How human populations develop and change

The characteristics studied by physical anthropologists—such as eye colour, nose shape, blood type, body height, and susceptibility to genetic diseases—are determined by both heredity and the environment. The inherited aspects of a trait are determined by tiny biochemical structures in cells, called *genes.* Genes contain chemical instructions for the formation of hereditary characteristics. Children inherit half their genes from their father and half from their mother. The underlying genetic makeup of a trait is called the *genotype.* The actual appearance of the trait is called the *phenotype.* The phenotype results from the environment and heredity.

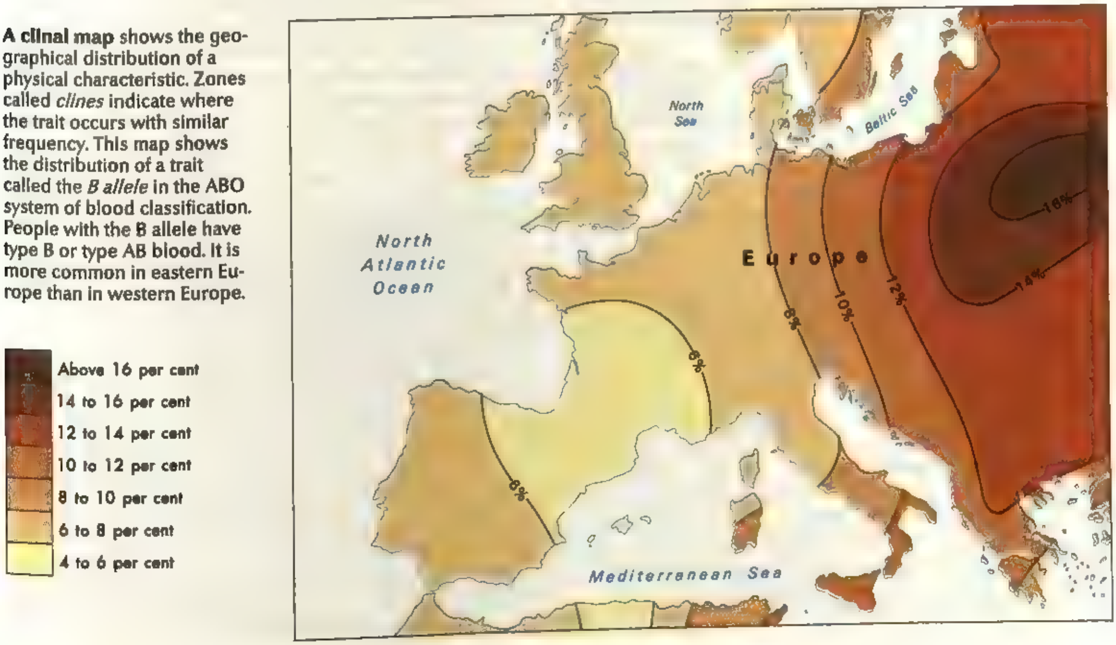
Members of the same population of human beings tend to have more genes in common than do members of different populations. Closely related populations also share more genes than do distantly related groups, just as cousins have more genes in common than do members of different families. All the genes in a population are called the group's *gene pool.* The degree to which a gene is present in a population is called the *gene frequency.* For more information on how characteristics are inherited, see **Heredity; Cell; Gene.**

Scientists have shown that the gene pools of human populations can change over time. The presence of some genes increases, while the presence of other genes declines. As gene frequencies change, the frequencies of physical characteristics in a population may also change. Such changes can result from a number of different factors, including (1) natural selection, (2) mutation, (3) genetic drift, (4) the founder effect, and (5) migration and gene flow.

Natural selection is the process that enables some organisms or individuals to live and reproduce while others do not survive. Those who reproduce pass their genetic characteristics on to their offspring. Natural selection is the force that drives Darwinian evolution. For example, certain individuals within a population might possess a genetic characteristic that provides resistance to a local disease. As a result, those individuals tend to survive longer and to produce more offspring than the other members of the population. Moreover, their children who inherit the favourable characteristic will likewise tend to live longer and leave more descendants. Over time, individuals who possess the favourable trait will tend to outnumber those who do not, and the gene frequencies of the population will have changed.

As a result of natural selection, a population that lives in a certain area for many generations tends to exhibit

A clinal map shows the geographical distribution of a physical characteristic. Zones called *clines* indicate where the trait occurs with similar frequency. This map shows the distribution of a trait called the *B allele* in the ABO system of blood classification. People with the B allele have type B or type AB blood. It is more common in eastern Europe than in western Europe.



distinctive genetic traits or clusters of traits. Scientists have demonstrated that differences in skin colour, body build, and many other physical characteristics represent adaptations to different environmental factors. See **Natural selection.**

Climatic adaptations. The genetic makeup of populations may change over time to adjust to climate. For example, dark and light skin and eye colour represent adaptations to different amounts of sunlight. The colour of our skin, hair, and eyes is determined by the pigment melanin. The amount of melanin in the skin, hair, and eyes can differ greatly from one person to another. Large amounts of melanin in the skin help protect it from sunburn and reduce the risk of skin cancer. Dark pigment in the eyes improves vision in bright sunlight. Therefore, dark skin and dark eyes represent adaptations of people whose ancestors have lived for many generations in sunny climates.

Sunlight also affects skin colour in another way. Our bodies need vitamin D to help us absorb calcium. The absorption of sunlight enables our bodies to make vitamin D. In climates with long winter nights, it can be difficult for our bodies to absorb the sunlight needed to make enough vitamin D. People whose ancestors have lived in these climates for generations have adapted to reduced sunlight by developing light-coloured skin that will absorb the little sunlight that is available. Therefore, skin colours in humans result from adaptations to the environments in which our ancestors have lived.

Human populations also differ in response to cold. Among Eskimos (also called *Inuit*), for instance, the body maintains a high temperature by burning large amounts of fat and protein. It also keeps large amounts of blood flowing to the arms, legs, fingers, and toes, to prevent frostbite. The Australian Aborigines, who live in a generally warm climate but traditionally slept in below-freezing temperatures with little clothing or shelter, have adapted to cold in a different way. The temperature in their legs and feet drops during sleep, and they burn less energy. But their bodies maintain warmth in the trunk, where the vital organs are.

The Australian Aborigines and the Eskimos of the Arctic have both adapted to cold. The Aborigines have a limited food supply. They have no extra food to burn for body heat when the temperature drops. Instead, their adaptation enables them to save body energy. But this method would not work in the Arctic, where the climate is cold day and night. The Eskimos are adapted to extreme cold—temperatures as low as −40° C to −51° C. Their adaptation depends on the availability of food to supply energy and body heat.

Susceptibility to genetic diseases. Many of the diseases that afflict human beings have some genetic basis. Human populations differ in the frequency of the genes that cause certain genetic diseases and disorders. For this reason, a number of genetic diseases are distributed differently throughout the world and affect some populations more than they do others. The fact that certain populations are plagued by particular genetic diseases can be explained in terms of natural selection.

The frequency of a hereditary blood disorder called *sickle cell anaemia* varies widely in different populations. Individuals who inherit the sickling gene from both parents suffer from sickle cell anaemia. Most cases of this disease are fatal. *Carriers*—people who inherit the defective gene from only one parent—may have almost no problems or experience only mild symptoms. But they can transmit the abnormal gene to their children. See **Sickle cell disease.**

Scientists have found that carriers of the sickling gene have a higher resistance than noncarriers to *malaria,* a dangerous disease transmitted by certain mosquitoes. Sickle cell anaemia is a rare disorder, but it occurs more often among populations of western Africa, the Middle East, southern Europe, and the Caribbean, most of whom live in areas threatened by malaria. Thus, the sickling gene—despite its negative effects—represents an important advantage for people in these areas.

Another genetic disease, *cystic fibrosis,* is more common among European populations and their descendants than among other populations. This rare and incurable disease affects the lungs and other organs. Like sickle cell anaemia, cystic fibrosis results from the inheritance of a disease-causing gene from both parents. Carriers of the gene do not contract cystic fibrosis, but they can pass it on to their offspring. Medical geneticists have found that carriers are more resistant than other individuals to *tuberculosis,* an infectious disease affecting the lungs. Tuberculosis swept through Europe from the 1700's to the early 1900's. Carriers of the cystic fibrosis gene would have been more likely to survive these epidemics, which could explain the relatively high frequency of the cystic fibrosis gene in these populations. See **Cystic fibrosis.**

Mutation. A mutation is a change in genetic material. A changed gene often produces a different inherited trait that can be passed on to future generations. Mutations result from a chemical change in *DNA* (deoxyribonucleic acid), the chief chemical compound of genes. Mutations may also result from a change in the number or arrangement of *chromosomes,* the threadlike structures that contain the genes. Scientists know of many agents that can cause mutations, such as certain types of radiation, chemical treatments, and heat, but they cannot tell in advance which genes or chromosomes will mutate or how the trait controlled by that gene or chromosome will change.

Many mutations are harmful, causing mental or physical disorders. But other mutations are neutral, and some are favourable. A favourable mutation may provide the raw material for natural selection by making a person better suited to the environment. For example, a mutation that enhances the body's ability to make vitamin D from sunlight would be advantageous to a person living in the far North, where the earth receives less sunlight. Such beneficial genes will increase in frequency from generation to generation. However, individuals possessing harmful mutations may be selected against, so the trait will not tend to increase in a population. In this way, mutation sometimes works together with natural selection to produce changes in gene frequencies. See **Mutation; Heredity** (Heredity and change); **Nucleic acid.**

Genetic drift refers to chance fluctuations in the gene frequencies of a population from generation to generation. The genes of each generation represent only a sample of the previous generation's gene pool. As a result, the gene frequencies of each generation of individuals tend to vary randomly within the limitations

of the preceding generation's gene pool. The smaller the population, the stronger the impact of these fluctuations is likely to be. Such changes are not likely to have much effect in very large populations, but they can lead to significant genetic changes in small populations.

The founder effect. When a small number of people from a large population establish a new population in a different place, it is unlikely that the founders represent the full range of diversity in their parent population's gene pool. When these founders produce offspring, a smaller, more limited gene pool is created. This phenomenon is called the *founder effect.* In future generations, the members of a population influenced by the founder effect are likely to resemble one another more closely than they do the members of the larger, more diverse parent population.

The founder effect may explain the increased incidence of certain traits or diseases in a population. For example, a hereditary brain disorder called *Tay-Sachs disease* occurs mainly among Jewish children of eastern European ancestry. People with one Tay-Sachs gene do not have the disease but may transmit the gene to their children. Children who inherit the gene from both parents have the disease. The Jews of eastern Europe made up a small population with a limited gene pool, so the incidence of the disease remains higher among their descendants than in other populations. See **Tay-Sachs disease.**

A similar limitation on a population's gene pool may occur if the genes of one person or family in a small population are passed to a large number of offspring. For example, if one man in a small, isolated group married several women and fathered many children, his genes would appear in future generations with more frequency than would the genes of other members of the population.

Migration and gene flow. When migration occurs between separate populations, new genes or combinations of genes are likely to be introduced into each group through interbreeding. As a result, the gene pool of each group comes to include genes from the gene pools of the other populations. In this manner, migration may cause the gene frequencies of populations to change over time. In modern times, easy access to transportation has greatly increased gene flow.

Since earliest times, people have moved from one place to another and have chosen mates from other groups. The greatest amount of gene flow occurs between populations that live next to one another. Mixture may also occur as a result of various cultural practices. Throughout history, such practices as exploration, colonization, bride capture, and enslavement have brought individuals of various genetic makeups together. The result in many cases has been change in the gene frequencies of the populations affected by these practices.

The social significance of race

As we have seen, most physical anthropologists have abandoned the idea of classifying human beings into biological races. In many societies, however, people continue to identify themselves and others as members of a particular race, often based on skin colour. Thus, whatever its shortcomings on a biological basis, racial classification remains an important sociological factor. Social scientists must recognize the way a society defines racial categories if they hope to understand human behaviour. It would, for instance, be difficult to analyse American society without taking into account the commonly used division of that society into "white," "black," "Hispanic," and other races. Yet these categories themselves reveal problems with the concept of race. "White" and "black" represent categories traditionally used to identify biological races. But "Hispanic" refers to the language group of Spanish-speaking people, not to any one biological group. Unfortunately, many social distinctions between races result from racial prejudice and misunderstanding.

Race and ethnic or national identity. The biological concept of race is sometimes confused with the idea of ethnicity or nationality. People identify themselves as members of certain ethnic or national groups based on certain geographical, cultural, or religious characteristics. However, these identifications are not based on physical differences. For instance, people sometimes incorrectly speak of the "Arab race," the "German race," the "Irish race," or the "Jewish race." But these labels refer to ethnicity or nationality and have nothing to do with the biological concept of race.

Race and discrimination. History includes many episodes in which the members of one group of people

Migration can lead to changes in the gene frequencies of populations over time. The photograph on the left shows newly arrived European immigrants on Ellis Island, a United States immigration station in New York Harbor, about 1900.

deemed themselves superior to another group. Such beliefs were long used to rationalize the enslavement and persecution of people viewed as inferior. For example, the ancient Romans viewed the Germanic tribes as a "race" of barbarians who were barely human. Europeans who settled in America claimed superiority over the American Indians to justify their expansion into the New World. In the 1930's, the leaders of Nazi Germany preached that Germans belonged to the "superior Aryan race," and that Jews and all other non-Aryan peoples were inferior.

Experts have not discovered any scientific basis for such claims of superiority. But many people still view other groups in terms of *stereotypes.* That is, they have oversimplified, preconceived, and generalized beliefs about the members of these groups. At various times, for example, certain groups have been described as dirty, dishonest, sly, humourless, or dull. These judgments have often been confused with racial traits, though they have nothing to do with the biological concept of race. Many such judgments have nothing to do with culture either, but only with the opinions or prejudices of those who make them. Discrimination can result from these stereotypes. As a result of these beliefs, members of minority groups in many societies have fewer educational and job opportunities than do members of the majority group.

The belief that some groups are more intelligent than others has been used to justify discrimination. Scientists have shown that a person's intelligence is partly inherited and partly determined by the environment. The use of intelligence to compare groups of people is extremely difficult, because few such comparisons can be considered equal. A better-educated group, for example, will score higher on tests that measure education. Groups that value mathematical skills or technical ability will do better on tests involving such skills and knowledge.

Many experts believe it is impossible to design an intelligence test that is not influenced by a person's experiences. Nevertheless, scientists are trying to develop *culture-fair* or *culture-free* tests that reduce the effects of cultural differences on test scores.

The differences among human beings make the world a fascinating place in which to live. But when people focus on these differences, they often fail to appreciate how similar all human beings are. Most of the distinctions people make between themselves and others have much more to do with culture than with biology.

Related articles. See the separate ***World Book*** articles listed under "People" at the end of Africa and Asia. See also:

Adaptation
Africa (People)
Aleuts
Asia (People)
Australian Aborigines
Dyaks
Europe (People)
Evolution
Heredity
Indian, American
Inuit
Latin America (People)
Maori
North America (People)
Pacific Islands (People)
Prehistoric people
Racism

Outline

I. Systems of racial classification
A. The three-race theory
B. Evolutionary theory
C. The geographical-race theory

II. Alternatives to racial classification
A. The clinal approach
B. The population approach

III. How human populations develop and change
A. Natural selection
B. Mutation
C. Genetic drift
D. The founder effect
E. Migration and gene flow

IV. The social significance of race
A. Race and ethnic or national identity
B. Race and discrimination

Questions

How do mutations lead to changes in human populations?
Why might the disease cystic fibrosis affect mainly members of European populations and their descendants?
Why do most physical anthropologists doubt that "pure" races ever existed?
Why were natural barriers considered important in the geographical-races theory?
What are difficulties in using intelligence as a basis for comparing groups of people?
What is a *nonadaptive* trait?
How can large amounts of melanin be helpful under some conditions and harmful under others?
What is natural selection? How does it cause human populations to change?
How do anthropologists use clines to study human variations?
How does a race differ from a species?

Rachel, in the Old Testament of the Bible, was the favourite wife of Jacob. Jacob served her father, Laban, seven years to win her, and his love was so great, "they seemed to him but a few days" (Genesis 29:20). But then Laban tricked him and gave him Rachel's older sister, Leah, instead. Jacob married Rachel a week later, but had to work another seven years for her. Rachel's first child was Joseph, who became his father's favourite. Rachel died after giving birth to Benjamin. Rachel was considered the ancestress of the northern Israelite tribes of Ephraim and Manasseh, which claimed descent from Joseph. A century after the Assyrians deported part of the tribes in 722 or 721 B.C., Jeremiah described Rachel as mourning over her lost children (Jeremiah 31:15).

See also **Jacob.**

Rachmaninoff, Sergei Vassilievich (1873-1943), was a Russian composer and director and one of the greatest pianists in music history. His compositions generally carry the late romantic style of Russian composer Peter Ilich Tchaikovsky into the early 1900's. Even Rachmaninoff's last works from the 1930's are hardly affected by modern trends. His music is strongly influenced by the chants and church bells of the Russian Orthodox Church. These influences appear in Rachmaninoff's severely simple melodies and rich, full keyboard sounds. He combined these native Russian materials with his own passion and intensity of expression.

Sergei Rachmaninoff

Rachmaninoff gained his greatest international reputation for his piano compositions. His most famous

work is the Prelude in C-sharp minor for piano. He composed it in 1892, at the age of 19. The second (1901) of his four piano concertos shows the melancholy lyricism of his mature style and his skilful writing of virtuoso piano compositions. His other work for piano and orchestra is the *Rhapsody on a Theme by Paganini* (1934).

Rachmaninoff's major works for orchestra are his three symphonies (1897, 1908, and 1936), the symphonic poem *The Isle of the Dead* (1909), and *Symphonic Dances* (1941), and the choral symphony *The Bells* (1913). The composer based *The Bells* on a Russian translation of the poem by the American author Edgar Allan Poe.

Rachmaninoff's main works for solo piano appear in the collections *Moments musicaux* (1896), two sets of *Preludes* (1903, 1910), and two sets of *Études-tableaux* (1911, 1917). He also wrote more than 80 songs, all to Russian texts, for solo voice and piano accompaniment. They include "Lilacs," "Spring Waters," "How Fair This Place," and "Vocalise." He composed three operas, but none are widely performed today.

Rachmaninoff was born on his family estate near Novgorod. In 1885, he entered the Moscow Conservatory to study piano and also to begin courses in composition, orchestration, and counterpoint. Rachmaninoff completed his piano studies at the conservatory in 1891. He graduated in composition the next year, winning the conservatory's highest award for his one-act opera *Aleko.*

In 1902, Rachmaninoff married his cousin Natalya Satina. He was conductor of the Bolshoi Opera in Moscow from 1904 to 1906 and made his first tour of the United States in 1909 as a pianist and conductor. Rachmaninoff left Russia with his wife and two daughters in 1917 and never returned. Eventually, he settled in the United States late in 1918.

In America, Rachmaninoff concentrated primarily on concert performances rather than composing. He gained enormous popularity with American and European audiences both for his compositions and as a piano soloist. He lived in Switzerland for much of the 1930's but returned to the United States in the late 1930's. He died in the United States shortly after he received his American citizenship.

Racial segregation. See **Segregation.**

Racine, Jean (1639-1699), ranks among the greatest French playwrights. Racine wrote during the French Classical Age. He followed the classical rules for composition, including the use of a single concentrated plot. The outstanding feature of Racine's art is its simplicity. He used a limited vocabulary and his plots contain very little action.

Almost all of Racine's important plays are tragedies. All of his tragic heroes follow the same pattern. They are victims of violent passions which they cannot control, and they ignore reality and try unsuccessfully to impose their wills on other persons. In the process, most of them cause the death of those they love most. In the end, the heroes recognize their illusions and accept the misery of the human condition as unavoidable. In this respect, Racine is close in spirit to the Greek playwright Sophocles. Racine's theory of tragedy has much in common with Aristotle's literary essay, *Poetics.*

Racine wrote in 12-syllable couplets, as did his rival Pierre Corneille. But Racine used a simpler style.

Racine was born in La Ferté-Milon, near Meaux, and was educated by distinguished teachers belonging to the strict Jansenist religious sect. He showed promise of a literary career at an early age. In 1664, Racine staged *La Thébaïde,* his first tragedy to be produced. It met with little success. His next play, *Alexandre* (1665), enjoyed considerable acclaim.

With the production of *Andromache* (1667), Racine became known as one of the greatest dramatists of his time. His next seven plays are masterpieces. They are *Les Plaideurs* (1668), his only comedy; and the tragedies *Britannicus* (1669), *Bérénice* (1670), *Bajazet* (1672), *Mithridate* (1673), *Iphigénie* (1674), and *Phèdre* (1677). In 1677, Racine retired from the stage. Later, he wrote *Esther* (1689) and *Athalie* (1691), tragedies based on stories from the Old Testament.

See also **Drama** (Neoclassical playwrights); **French literature** (The classical age).

Racing is a contest of speed. People compete in running, swimming, and walking races. Such sports as horse racing and motor racing involve people riding animals or operating machines. Trained animals compete against one another in dog racing and pigeon racing. Some races rank among the world's most popular spectator sports, attracting millions of people every year. Besides the spectators who attend major races, many more watch such events on television.

Racing includes both individual and team competition. In some races, winners are determined only by the fastest time. In other races, the winner is the competitor who finishes first. Some races last only a few seconds. Some other races are very long and test endurance as well as speed. A well-known example is the marathon, a running race of 42.2 kilometres. Some ocean yacht races and bicycle road races last for weeks.

Racing events have been popular throughout human history. A footrace was the only event in the early Olympic Games in ancient Greece during the 700's B.C. More recently, racing has contributed to improvements in design and performance in bicycles, boats, and cars.

Related Articles in *World Book* include:

Athletics
Bobsledding
Canoeing (Canoe racing)
Car racing
Cycling
Dog racing
Homing pigeon
Horse racing
Ice skating (Speed skating)
Iceboating
Motorboat racing
Motorcycle
Olympic Games
Roller skating
Rowing
Sailing (Sailboat racing)
Skiing
Swimming
Walking

Racism is the belief that human beings can be divided into races and that members of some races are inferior to members of other races. Usually, this attitude also involves the belief that one's own race is superior to other races. People who believe in or practise racism are called *racists.* They claim that members of their own race are mentally, physically, morally, or culturally superior to those of other races. Because racists assume they are superior, they believe they deserve special rights and privileges.

Groups, as well as individuals, differ. But there is no scientific evidence to support claims of superiority or inferiority for these differences. Social scientists empha-

size that no two groups have exactly the same environment. As a result, many group differences are largely the result of different environments. Scientists have long debated the relative importance of heredity and environment in determining these differences. But most scientists believe that heredity and environment interact in complex ways. In addition, most anthropologists today reject the idea that human beings can be divided into biologically defined races. For a discussion of these ideas, see the articles on **Intelligence** (Controversy over intelligence) and **Races, Human** (Race and discrimination).

Racism is widespread and has caused major problems, even though no scientific proof supports racist claims. Claims of racial superiority and inferiority have been used to justify discrimination, segregation, colonialism, slavery, and sometimes even *genocide* (mass murder).

Racism is a form of prejudice. Many people tend to consider their own appearance and behaviour as normal and therefore desirable. They may distrust or fear people who look or act differently. When differences are obvious—such as in skin colour or religious worship—the distrust becomes greater. Such attitudes can lead to the belief that people who look or act differently are inferior. Many people do not look for the same qualities in other groups that they admire in their own. Also, they do not recognize the different but equally good qualities that members of other groups possess.

Racism in countries where whites form a majority is directed mainly by the white majority against ethnic minority groups. Such groups include blacks, American Indians, Mexican Americans, Australian Aborigines and Asians. These minorities have been discriminated against in such areas as housing, education, and employment. For a detailed discussion of such discrimination, see **Segregation; Minority group; Ethnic group; Australian Aborigines;** and **Indian, American.**

In South Africa, a white *minority* controlled the government for many years. It imposed racist laws affecting housing, education, and employment on the much larger nonwhite majority. This policy was known as *apartheid.* See **Apartheid.**

Individual and institutional racism. Sociologists often distinguish between individual and institutional racism. Individual racism refers chiefly to the prejudicial beliefs and discriminatory behaviour of individual whites against blacks and other minority groups. It is based on assumptions of superiority and inferiority.

Institutional racism, on the other hand, refers to the policies of communities, schools, businesses, and other groups and organizations that restrict the opportunities of minority groups. Institutional racism may or may not have been intentionally set up to practise discrimination. Regardless, it can produce harmful results. For example, a company may hire only college graduates for work that does not require a college degree. But a far smaller proportion of blacks than whites may have had the opportunity to earn a degree. Thus, the company policy lessens the job opportunities of blacks even though the firm might not have intended to do so.

History. Forms of racism have existed since the beginning of history. More than 2,000 years ago, for example, the ancient Greeks and Romans made slaves of people whom they regarded as inferior. Jews have long been persecuted on religious and cultural grounds. For hundreds of years after Marco Polo's travels to China in the 1200's, the Chinese regarded Westerners as "hairy white barbarians."

Between the 1700's and early 1900's, Europeans gained control of large parts of Asia and Africa. These colonialists justified their domination on the grounds that the black-, brown-, and yellow-skinned "races" had to be "civilized" by the "superior" whites. This civilizing mission came to be called the "white man's burden." Throughout the British Empire, white supremacy was assumed in most areas of life. In colonial India, for example, there was little social intermixing between native Indians and white officials. In Australia, white settlers regarded the Aborigines as inferiors. By the mid-1900's, most colonialism had ended. But its effects on the world are still felt today. For details, see the articles on **Africa** (History) and **Asia** (Results of colonialism; The spread of Communism).

From the 1600's to the mid-1800's, many whites in the United States held blacks in slavery. Slavery was a major cause of the American Civil War (1861-1865). The slaves were freed during the 1860's, but segregation and discrimination against blacks continued.

Legislation has been passed to combat racism, and to promote equality of opportunity in multiracial societies. Such laws make discrimination unlawful on grounds of colour, nationality, or ethnic origin in such areas as providing goods and services, employment, and education. Criminal laws prohibit the incitement of racial hatred. In the United Kingdom, race relations laws were first passed in the 1960's, following the arrival of numbers of immigrants from the Caribbean, India, Pakistan, and later Bangladesh. The Race Relations Act of 1976 established the Commission for Racial Equality. Community relations councils operate at the local level. The United States government has passed a number of laws designed to give equal opportunities to blacks and other disadvantaged groups. Even so, racial problems continue to plague the United States.

Genocide is the most extreme result of racial hatred. Adolf Hitler, the ruler of Nazi Germany, preached that Germans belonged to the "superior Aryan race," and that Jews and other non-Aryan peoples were inferior. Hitler's belief in German superiority and his hatred of Jews resulted in Nazi policies that brought the murder of about 6 million Jews during the 1930's and 1940's. See **Jews** (Beginnings of Nazi persecution).

Related articles in ***World Book*** include:

Anti-Semitism
Apartheid
Genocide
Immigration
Prejudice
Race relations laws
Races, Human
Slavery

Rack was an instrument of torture often used in the Middle Ages. The victim was bound on an oblong wooden frame with a roller at each end. If the victim refused to answer questions, the rollers were turned until the victim's joints were pulled out of their sockets. The rack was used by the Romans and was a favourite tool of the Spanish Inquisition.

From *Alice's Adventures in Wonderland* by Lewis Carroll. Illustrated by Arthur Rackham.

A Rackham illustration from 1907 shows the artist's detailed style. In this scene from *Alice's Adventures in Wonderland,* Alice and the Gryphon listen to the Mock Turtle's sad life story.

Rackham, Arthur (1867-1939), an English artist, won wide recognition for his illustrations for children's books. His illustrations were filled with such figures as gnomes, elves, witches, and fairies, as well as with kindly human creatures.

Rackham drew and painted these figures with delicacy and rich detail. He made such details as wood grain, tree bark, and lines in faces and hands important parts of the whole design. He even gave his trees personalities. Rackham's imaginative and skilful pictures brought to life the characters in many favourite stories, including *Rip Van Winkle* (1905), *Peter Pan in Kensington Gardens* (1906), *Alice's Adventures in Wonderland* (1907), *Mother Goose, the Old Nursery Rhymes* (1913), and *Some British Ballads* (1919).

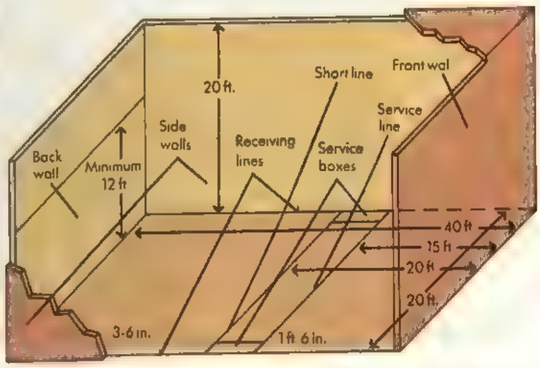
Rackham was born in London. He became interested in drawing as a boy and entered the Lambeth School of Art in 1884. The first illustration he sold appeared in the periodical *Scraps* in that year. Rackham also contributed to other periodicals including the *Pall Mall Budget* and *Cassell's Magazine.* He supported himself by working in an insurance office from 1885 to 1892. He developed his imaginative style in the 1890s. Rackham first gained recognition for his illustrations in an edition of *Grimm's Fairy Tales* published in 1900.

See also Literature for children.

Racquetball is a fast, exciting game played mostly in the United States. The players hit a ball with a short racket (also spelt racquet) that resembles a small tennis racket. They play with a hollow rubber ball about the size of a tennis ball. Most racquetball games are played on indoor courts that are 20 feet (6.1 metres) high, 40 feet (12.2 metres) long, and 20 feet (6.1 metres) wide. The game can be played with one or two players on a side. In cut-throat racquetball, three players compete against each other.

A racquetball game starts with a *serve.* The server stands between the *service line* and the *short line* with the receiver or receiving team standing behind the short line. The server drops the ball on the floor and hits it on the first bounce. The ball must strike the front wall and rebound behind the short line. The players or teams then take turns hitting the ball. Each player in turn must return the ball before it bounces twice on the floor. A player can return the ball by hitting it against any wall or the ceiling. But the ball must strike the front wall before it touches the floor.

The server or serving team scores points if an opponent fails to return the ball properly. The side continues the serve after each point until it makes an error on its serve or fails to win the point. The other side then serves. Originally, games were played to 21 points. Most games now go to 15 points. The first side to win either two or three games wins the match.



A racquetball court has four walls. The server stands between the *short line* and the *service line.* During the serve, the ball must hit the front wall and bounce behind the short line. The opponent waits for the serve behind the *receiving lines.*

Racquetball is an exciting, fast-paced sport played in a four-walled court. Players, using rackets, take turns hitting a ball off the walls and ceiling of the court.

Radar enables an air traffic controller to track and guide planes in flight. Radio waves reflected from the planes appear as small spots on the controller's screen, *above.* The flight path of every plane in the area can be determined by following the movements of the spots.

Radar

Radar is an electronic system used to detect and locate moving or fixed objects. Radar can determine the direction, distance, height, and speed of objects that are much too far away for the human eye to see. It can find objects as small as insects or as large as mountains. Radar can operate effectively at night and even in heavy fog, rain, or snow.

The ability of radar to do so many tasks makes it useful for a wide variety of purposes. Pilots rely on radar to land their aeroplanes safely at busy airports. In bad weather, ship navigators use it to steer their ships clear of nearby vessels and dangerous objects. Many countries use radar to guard against surprise attacks from enemy aircraft or missiles. Radar enables weather forecasters to keep track of approaching storms. Scientists use radar to investigate the upper atmosphere of the earth. They also use radar to study the other planets and their moons.

The word *radar* comes from *ra*dio *d*etection *a*nd *r*anging. Almost every radar set works by sending radio waves toward an object and receiving the waves that are reflected from the object. The time it takes for the reflected waves to return indicates the object's *range*—how far away it is. This, together with the direction from which the reflected waves return, tells the object's location.

Radar sets vary in size and shape, but they all have the same kinds of basic parts. Every set has a transmitter to produce radar signals and an aerial to send them out. In most types of radar, the same aerial collects the waves bounced back from an object. The reflected waves, commonly called *echoes,* are strengthened by a receiver so they can be seen on a *display.* The typical radar display resembles the picture tube of a television set, but the screen is often circular instead of rectangular. It shows the echoes as spots of light or as an image of the object observed.

The uses of radar

In aviation. Radar is an important tool in aviation. Its use both at airports and in aeroplanes has contributed greatly to aviation safety.

Air traffic near large airports is extremely heavy. Specially trained *air traffic controllers* at all the world's major airports use radar to direct the continuous flow of incoming and outgoing planes. Radar shows the controllers the position of every plane in the air within at least 80 kilometres of the airport. This information enables them to prevent collisions by selecting the safest routes for pilots to follow. The controllers also depend on radar to enable them to direct landings from the ground when bad weather makes approach lights and runways difficult for pilots to see.

A system called *secondary radar* identifies aircraft on the screens of air traffic controllers. The radar signal triggers a transmitter on the aircraft so that it sends back a coded signal containing the aircraft's call sign. This is displayed on the screen alongside the spot representing the aircraft.

Most modern aircraft have various types of radar to aid pilots. For example, the *radar altimeter* shows how high a plane is flying and so helps pilots maintain the proper altitude. Another device, *weather radar,* detects nearby storms and thus enables pilots to change course to avoid rough weather whenever possible.

In ship navigation. Radar is widely used as a navigation aid on many kinds of boats and ships, from small pleasure craft to huge oil tankers. When visibility is poor, a ship's radar can spot other vessels, reefs, and icebergs in time to prevent an accident. When a ship is near shore, the navigator can determine the vessel's position by the radar echoes from special reflector buoys, islands, and other landmarks.

Harbour masters use radar to control ship traffic in crowded seaports. They follow the movements of all ships in a harbour on a radar display that provides a maplike picture of the harbour. By means of radio communication, harbour masters can guide ships into and out of a port safely in any weather.

Some coastguard stations keep track of vessels through radar observations. Coastguards also use radar to search for ships that are reported missing.

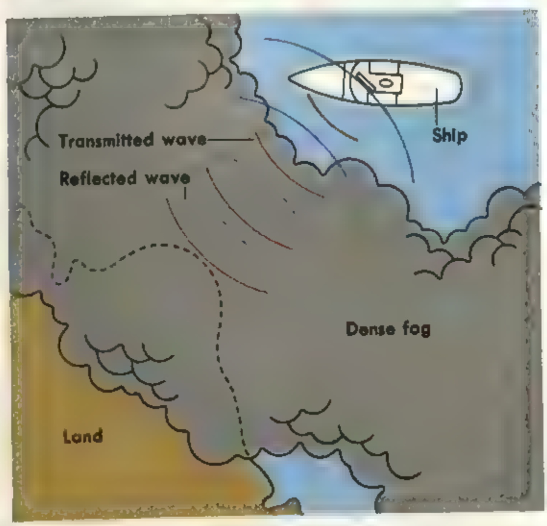
In the military. Radar has a variety of military uses. The major uses include (1) air defence, (2) missile defence, (3) space surveillance, (4) intelligence gathering, (5) range instrumentation, and (6) weapon fire control.

Air defence requires long-range radar that can detect and track approaching enemy aircraft at great distances and so give the earliest possible warning. Vast networks of radar stations form the heart of most nations' air defence systems. The North Warning System, a network of radar stations across northern North America, protects the United States and Canada from attack from the north. The U.S. also has built *over-the-horizon radar* stations to detect attacks from the east, south, and west.

In addition to land radar stations, several countries use aircraft equipped with radar for protection against surprise air attacks. Airborne radar can spot low-flying enemy bombers that may escape detection by ground-based radar.

Missile defence consists of radar networks like those used for early warning of hostile aircraft. But more powerful radar is needed to detect guided missiles because they fly faster and much higher than planes. The main radar network developed by the United States for missile defence is the Ballistic Missile Early Warning System (BMEWS). The system has installations at Clear, Alaska; Thule, Greenland; and Fylingdales Moor, England. Radar units at these installations can spot long-range missiles up to 4,800 kilometres away.

Space surveillance involves the use of extremely powerful radars to detect and track artificial satellites and other objects put into orbit around the earth. For this purpose, the United States and Canada operate a network called the United States Air Force (USAF) Spacetrack network. The network includes the three BMEWS installations and other facilities throughout the world. Each day, the USAF Spacetrack network



Boats and ships use radar as a navigation aid, especially to avoid obstacles when visibility is poor. Small vessels, such as the tugboat on the left, use a compact radar set with a rotatable aerial on top of the cabin. The diagram on the right shows how radar waves can penetrate dense fog. Their echoes enable a ship's navigator to detect land, reefs, or other vessels hidden by the fog.

Radar is vital to the defence of many countries. Powerful BMEWS radars warn against long-range missiles. Radars of the North Warning System detect aircraft approaching from the north, and over-the-horizon radars protect against attack from other directions. The United States Air Force (USAF) Spacetrack Network keeps track of artificial satellites orbiting the earth.

BMEWS–Ballistic Missile Early Warning System

North Warning System (selected sites)

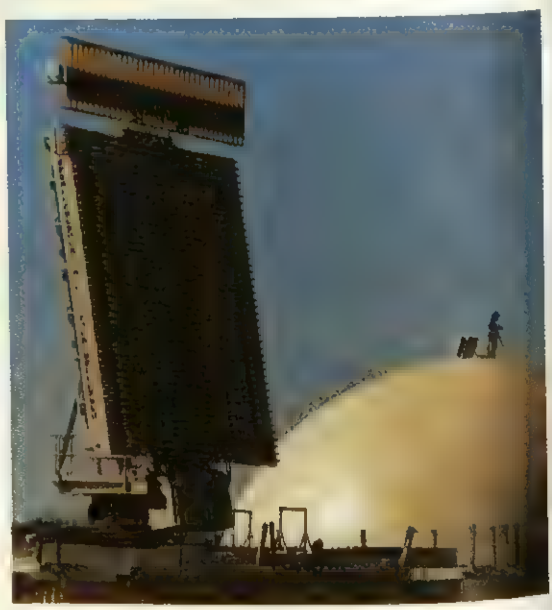
USAF Spacetrack Network

Over-the-horizon radars

provides about 20,000 observations of hundreds of orbiting objects. Data from these observations can help identify *reconnaissance satellites,* which are used for spying.

Intelligence gathering. Radar is used to collect information about the preparations that other countries might be making for war. A *mapping radar* in a plane can produce detailed maps of the ground and show military installations and equipment. Other types of radar can obtain important information about another country's missile systems by monitoring its missiles during test firings.

Range instrumentation. Radar is often used at test ranges to check the performance of military equipment. For example, *range instrumentation radars* can accurately track the flight of a new missile. If the missile does not perform as well as expected, the tracking data might help the designer determine what went wrong.



A long-range radar has a huge dome, *left,* which houses an aerial structure, *right,* that stands about 20 metres high. The radar shown here is part of the North Warning System, which was designed to replace the Distant Early Warning (DEW) line.

Weapon fire control. Radar can locate objects so precisely that it is used to aim and fire many kinds of weapons. Radar controls the firing of antiaircraft guns on tanks and warships. It directs guided missiles from jet fighters and from land-based launching sites. In addition, planes with radar bombsights can drop bombs accurately on targets at night or in bad weather.

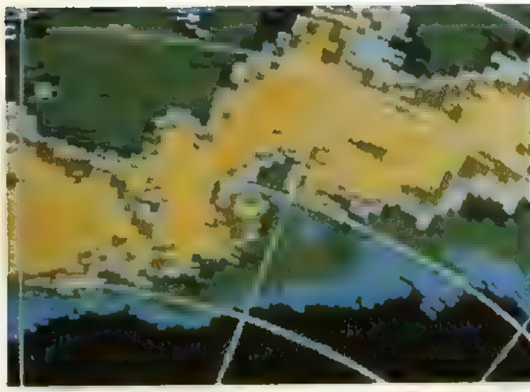
In controlling traffic speed and flow. Police in some countries use radar to enforce speed laws by checking the speed of motor vehicles on streets and highways. Their mobile radar sets can detect speeding vehicles up to about 800 metres away. The radar signals are emitted from an aerial mounted on the outside of a police vehicle.

In weather observation and forecasting. Radar has an important role in short-range forecasts of local weather conditions. Radar echoes can be detected from raindrops and ice particles in clouds up to about 400 kilometres away. In many cases, the intensity of these echoes reveals what type of storm is approaching. For example, strong echoes are produced by hailstones in a thunderstorm. Radar echoes also indicate the direction in which a storm is moving and its speed.

By analysing radar observations, weather forecasters can predict when a storm will pass over a certain area. In many cases, they can give advance warning to communities in the path of a hurricane, tornado, or other violent storm. Hundreds of ground and airborne radar units may be used to keep close track of such storms. Most major airports also have weather radar. If a severe storm is sighted along a particular flight path, air traffic is redirected to avoid it.

In scientific research. Scientists rely on radar in conducting various kinds of studies. They use high-powered radars to investigate the earth's upper atmosphere. At altitudes of 100 kilometres and higher, the air reflects radio waves. This air is in a part of the upper atmosphere known as the ionosphere. In this region, the sun's radiation is so strong that it breaks air molecules into electrically charged particles called *electrons* and *ions.* As a result, it can be studied by radar from the earth's surface. Radar observations help scientists determine the temperature of the upper atmosphere and the kinds of gases in the air. Radar observations also indicate how fast winds blow at such high altitudes during different periods of the day.

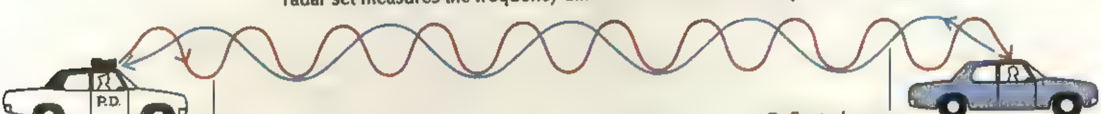
Radar equipment and techniques contribute much to the study of the solar system. Astronomers have made

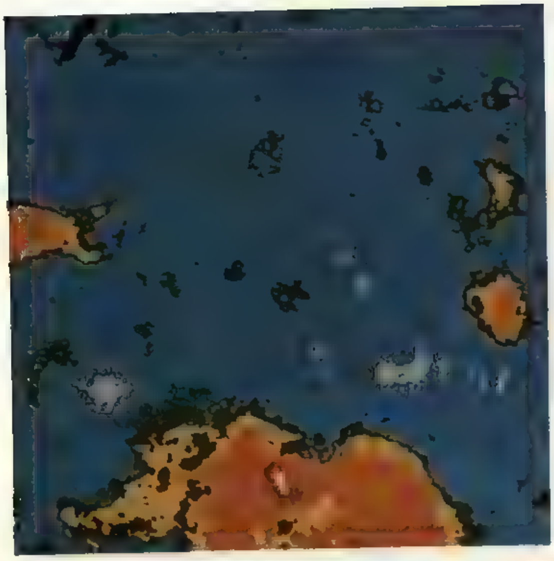


Weather radar can detect the formation and movement of storms by registering echoes bounced off raindrops and ice particles. This radar display shows a tornado forming.

How radar helps police catch speeders

Police use *Doppler radar* to detect speeding motorists. The radar aerial is mounted on the outside of a police car, *bottom left.* It launches a continuous radio wave of a certain frequency. When this wave strikes a moving car, it is reflected at a different frequency, as shown in the diagram. The radar set measures the frequency difference to find the car's speed and records it, *bottom right.*





A radar image of a volcano on Venus was made by a computer using data from a scan by the space probe Magellan. Heights in the image are exaggerated 10 times to show detail.

radar observations of the moon, the sun, and the planets closest to the earth. They have even collected radar echoes from several of Jupiter's largest satellites. Such radar observations provide extremely accurate measurements of the distances to these objects. They also show how rapidly the objects rotate. Astronomers have obtained detailed radar maps of the moon and Mars by recording radio waves bounced off their surfaces. With the same technique, they have succeeded in penetrating the thick clouds surrounding Venus and discovered enormous mountains and valleylike features on its surface. See **Radio telescope** (How a radio telescope works).

The study of bird migrations is another area of scientific research that has benefited from radar. Zoologists depend on radar to trace the flight patterns of birds that migrate at night or that are too small to be seen from the ground. Radar can also be used to measure and map currents on the ocean surface within about 70 kilometres from shore. Such information is useful for research in marine biology and in offshore oil-drilling projects.

In space travel. Radar is vital to the success of missions into outer space. The first step in such a mission is to launch a manned or unmanned spacecraft into orbit around the earth. During the launching, mission controllers use a system of ground-based radars and other radio equipment to track the vehicle. As soon as the spacecraft enters its orbit, the radars measure the orbit's size and shape. Computers take the measurements and calculate when the craft's remaining rocket engines should be fired and for how long to send the vehicle from earth orbit into outer space.

Spacecraft designed to land on the moon or on another planet carry *landing radar.* This equipment measures the height of the spacecraft above the landing site and the rate of descent. Such information is used to regulate the engines of the craft so that it lands at the correct speed. If the vehicle descends too fast, it will crash. If it lands too slowly, it will burn too much fuel. In addition, flight planners use radar to select safe landing sites for spacecraft. For example, radar maps of the moon helped U.S. scientists choose landing areas where there were no rugged rock formations to damage the Apollo lunar modules.

A mission may call for a spacecraft to dock with another space vehicle. The astronauts in the spacecraft locate the other vehicle with radar. They then use the radar data to adjust the direction and speed of their own craft to perform the docking manoeuvre.

How radar works

Radar sets differ in design and purpose, but they all operate on the same general principles. All radars produce and transmit signals in the form of *electromagnetic waves*—that is, related patterns of electric and magnetic energy. Radar waves may be either radio waves or light waves. Almost all radar sets transmit radio waves. But a few called *optical radars* or *laser radars* send out light waves.

When the electromagnetic waves transmitted by a radar set strike an object, they are reflected. Some of the reflected waves return to the set along the same path on which they were sent. This reflection closely resembles what happens when a person shouts in a mountain valley and hears an echo from a nearby cliff. In this case, however, sound waves are reflected instead of radio waves or light waves.

The waves transmitted by radar have a definite frequency. The frequency of such a wave is measured in units called *megahertz* (MHz). One megahertz equals 1 million *hertz* (cycles per second). Radio waves have lower frequencies than light waves. Most radars that transmit radio waves operate at frequencies of about 5 to 36,000 MHz. Optical radars operate at much higher frequencies. Some generate light waves with frequencies up to 1 billion MHz.

In many cases, radar sets designed for different purposes operate at different frequencies. Radars that transmit at lower frequencies are more effective than high-frequency radars in penetrating clouds, fog, and rain and so are widely used on planes and ships. On the other hand, high-frequency radars provide precise direction measurements with much smaller aerials than those used by lower frequency radars. An optical radar, for example, can produce an extremely narrow signal beam from a laser only about 1.3 centimetres in diameter. Optical radars are especially useful for surveying rough terrain where distant points have to be measured through the gaps between such objects as large rocks and trees. Over-the-horizon radars use relatively low-frequency radio waves between 3 and 30 MHz. These waves reflect from an upper layer of the atmosphere called the *ionosphere* and can reach beyond the horizon to detect ships and planes at great distances. Radars of the North Warning System use relatively high-frequency radio waves called *microwaves,* which pass through the ionosphere.

Radar sets also differ in how they transmit signals. On this basis, they are usually classified into two general types: (1) pulse radar and (2) continuous-wave radar. Pulse radar is the more common type.

Pulse radar sends out signals in powerful bursts, or pulses. These pulses last only a few millionths of a sec-

ond. A pulse radar set has one aerial, which alternately transmits the pulses and receives their echoes.

The distance to an object is found by measuring the time it takes a radar wave to reach the object and return. Radar waves, like all other electromagnetic waves, travel at the speed of light—299,792 kilometres per second. Therefore, a radar wave that returns after two seconds would have travelled 599,584 kilometres—299,792 kilometres to the object and the same distance back. A pulse radar set automatically converts the time required for the round trip into the distance to the object.

The aerial transmits the pulses of waves in a narrow beam, which enables the set to determine an object's direction. Only an object within the area of the beam can reflect the waves. The direction from which the waves are reflected to the aerial indicates the location of the object.

Pulse radar can track an object by continually transmitting signal pulses and by measuring the object's distance and direction at regular intervals. It can also be used to make radar maps from an aeroplane. Radar maps are produced by scanning a beam of pulses over an area and plotting the strength of the echoes from each direction. The echoes appear as images on the radar display and are recorded on photographic film. Such objects as buildings, bridges, and mountains produce especially bright images because they reflect strong echoes.

Continuous-wave radar sends out a continuous signal rather than short bursts. There are two kinds of continuous-wave radar. They are (1) Doppler radar and (2) frequency-modulated (FM) radar.

Doppler radar is used chiefly to make precise speed measurements. It works on the basis of the *Doppler effect,* which is a change in observed wave frequency caused by motion. Doppler radar transmits a continuous wave of a constant frequency and uses the same aerial for transmitting and receiving. When the outgoing wave strikes an object that is approaching the radar set, the wave is reflected at a higher frequency than the frequency at which it was sent out. When an object is moving away from the set, the wave is bounced back at a lower frequency. The faster an object moves in either direction, the greater the difference in frequency between the transmitted and reflected waves. By measuring the difference in frequency, Doppler radar determines the speed of the object observed.

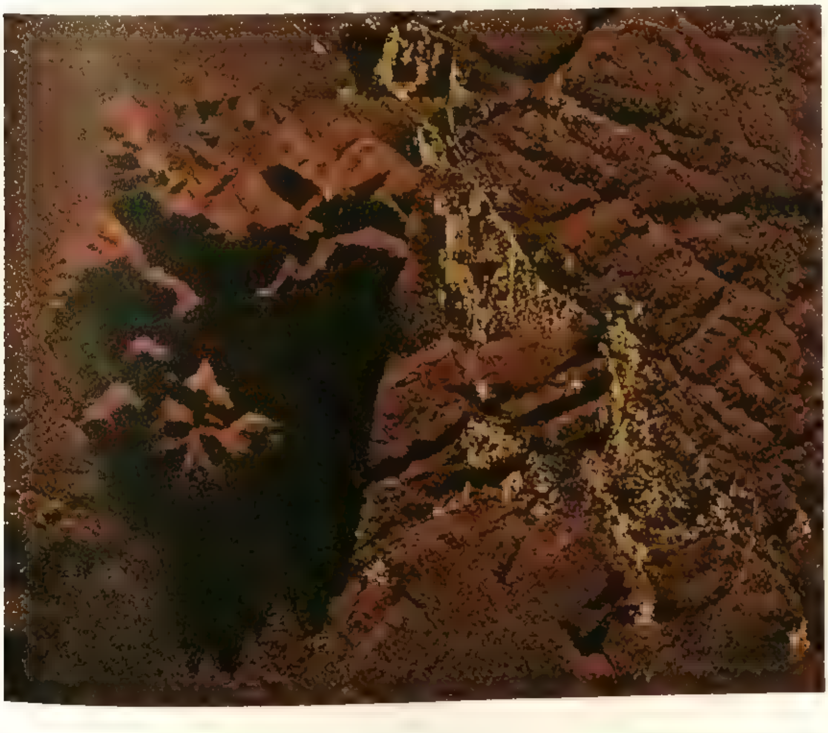
Police use Doppler radar to detect speeding motorists. Military personnel often use it to measure the velocity of targets for directing weapon fire.

Frequency-modulated (FM) radar also transmits a continuous signal, but it rapidly increases or decreases the frequency of the signal at regular intervals. As a result, frequency-modulated radar, unlike Doppler radar, can determine the distance to a moving or stationary object. By the time a radar signal reaches an object and returns, the frequency of the transmitter has changed. The difference between the frequency of the echo and that of the transmitter is measured and converted into the distance to the object that produced the echo. The farther away an object is, the greater the difference between the two frequencies.

Frequency-modulated radar, like pulse radar, can be used for mapping and tracking. It also serves as an altimeter for aeroplanes.

The parts of a radar set

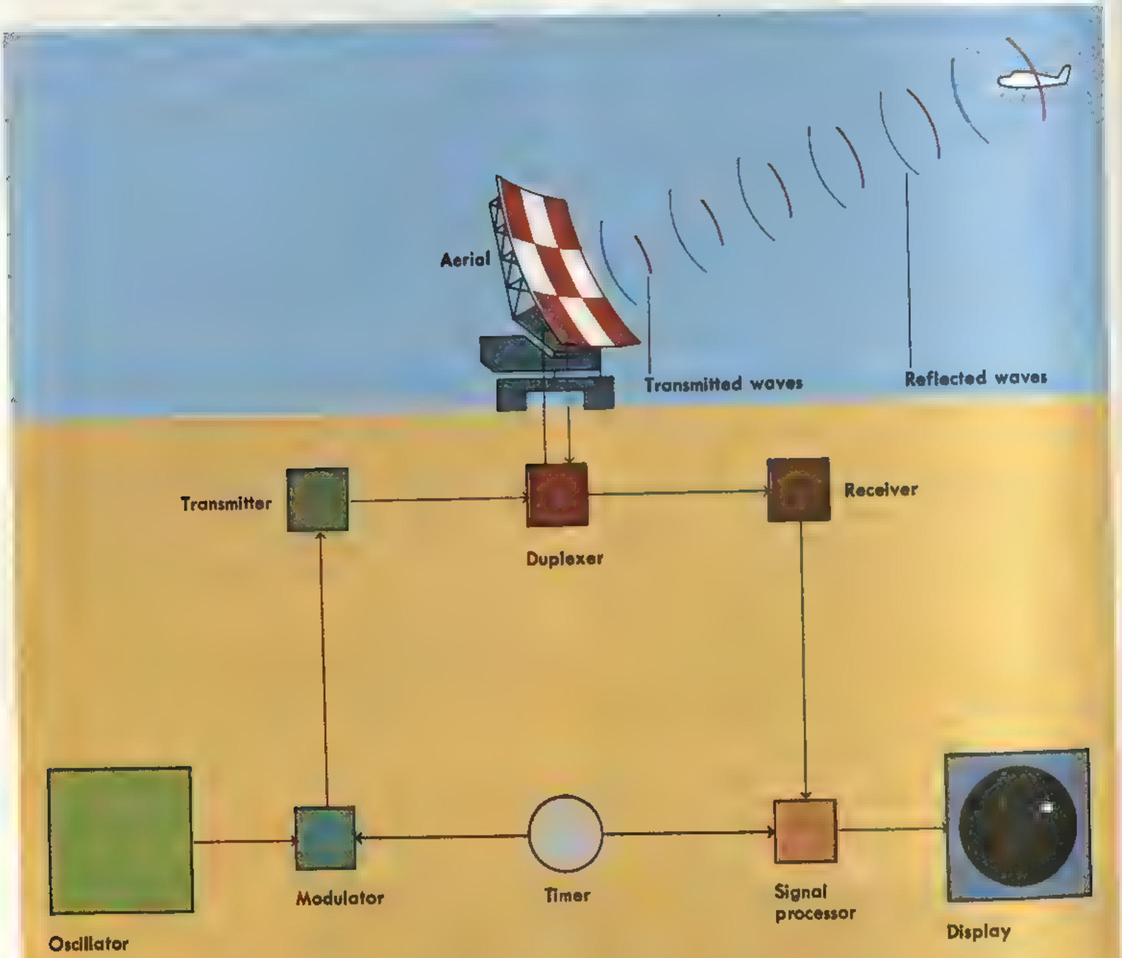
Radar sets range widely in size. The size of a unit depends mainly on its use. For example, the sets used by some motorcycle police to detect nearby speeding cars



Radar mapping can be done from an aeroplane. The radar map of Flagstaff, Arizona, U.S.A., on the left, was made from an altitude of about 12,000 metres. The city appears as a cluster of yellow images. The enormous landform to the left of the city is Elden Mountain.

How pulse radar works

Pulse radar is the most widely used type of radar. The diagram below shows the principal parts of a typical pulse radar set and illustrates how it detects a distant object.



Transmitting radar waves. The oscillator of a pulse radar set generates a low-power electric signal of a constant frequency. A modulator turns the transmitter on and off, causing the transmitter to produce short bursts of electromagnetic waves. The transmitter produces these high-power waves by amplifying the electric signal generated by the oscillator. A duplexer routes the waves from the transmitter to an aerial. After the waves have been transmitted from the aerial, the duplexer connects the receiver to the aerial, which then collects the waves reflected from an object.

Receiving reflected waves. The switching action of the duplexer enables the receiver to pick up the echoes collected by the aerial. The receiver amplifies the reflected waves and filters out much of the accompanying noise and interference. A signal processor takes the incoming waves from the receiver and combines them, which improves their quality. A display shows the echoes as spots of light or as an image of the object detected. A timer automatically turns the signal processor and the modulator on and off at the right time and so coordinates the operations of the radar set.

can be held in the hand. They weigh only about 1.8 kilograms. Many of the huge radar units used to study planets and other distant objects occupy large buildings. One radar unit is built into a valley and has an aerial that measures up to 300 metres in diameter.

Although radar sets differ in size, most have similar parts. These parts include (1) the oscillator, (2) the modulator, (3) the transmitter, (4) the duplexer, (5) the aerial, (6) the receiver, (7) the signal processor, (8) the display, and (9) the timer.

The oscillator is a device that generates a low-power electric signal of a constant frequency. The frequency of the oscillator determines the operating frequency of a radar set.

The modulator. In pulse radar, the modulator is an electronic switch that rapidly turns the transmitter on and off. It causes the transmitter to produce short bursts of waves. In frequency-modulated radar, the modulator varies the frequency of the continuously transmitted wave. Doppler radar has no modulator.

The transmitter serves as an amplifier. It takes the low-power electric signal generated by the oscillator and produces a high-power signal. For example, the transmitter of a pulse radar used in air traffic control

may produce signals with a peak power of several million watts.

The duplexer makes it possible to use one aerial for both transmitting and receiving. The duplexer routes the signals from the transmitter to the aerial and prevents them from flowing into the receiver. The powerful signals from the transmitter would damage the sensitive receiver if they flowed into it. After the signals have been transmitted as electromagnetic waves by the aerial, the duplexer connects the receiver to the aerial. This switching action enables the receiver to pick up incoming echoes.

The aerial sends out radar signals as a narrow beam of electromagnetic waves. It also collects the reflected echoes. Because most modern radar units have a duplexer, they use the same aerial for transmitting and receiving.

The most common type of aerial consists of a horn attached to the front of a large reflecting dish called a *reflector.* The horn launches the radar waves, and the reflector focuses them into a narrow beam. The aerial rotates so that the beam sweeps around the radar station, scanning for objects in all directions.

Other types of aerials are used in radar sets that operate either at relatively low frequencies or at extremely high frequencies. Radars that transmit low-frequency radio waves have an aerial made of metal tubes or rods. Such aerials resemble the outdoor aerials of TV sets. Radars that operate at optical frequencies use a device called a *laser,* which generates an intense beam of light. In optical radars, lenses control the size of the transmitted laser beam and capture the light waves returning from the target.

The receiver takes the weak echoes collected by the aerial and greatly amplifies them. It is so sensitive that it can easily detect echoes of less power than a millionth of a millionth of a watt. The receiver also filters out much of the noise and other interference picked up by the aerial.

The signal processor. In most radar sets, the incoming signals from the receiver pass through a signal processor before going to the display. The signal processor performs different tasks in radars used for different purposes. In many radar units, it blocks out echoes from large, fixed objects and allows only echoes from small, moving targets to reach the display. By doing so, the signal processor enables the operator of a radar set to see an aeroplane, for example, even though the echoes from the plane arrive at the same time as much stronger echoes from a mountain. A computer serves as the signal processor in most modern radars.

The display presents radar operators with information obtained about an object. Some sets have a simple display. The portable Doppler radars used by police, for example, have a meter that indicates the speed of a car or truck. However, most radar sets have a more complex display that consists of a *cathode-ray tube* (CRT). A CRT is a type of vacuum tube with a fluorescent screen like that of a TV set (see **Vacuum tube**). A CRT display can present radar data in several forms. The most common display is the *Plan Position Indicator,* generally called the *PPI.*

The PPI provides a circular, maplike picture of the area scanned by the radar beam. The centre of the picture corresponds to the location of the radar set. The screen has a compass scale around its edge for direction readings. The screen might also have rings spreading out from the centre of the picture to mark distance in miles or kilometres. Radar echoes appear as bright spots. The position of a spot with respect to the compass scale shows the direction of the object. The distance of the spot from the centre indicates how far away the object is. The speed of a moving object can be determined by noting the time it takes a spot to cover a certain distance on the radar screen.

Other forms of a CRT display show the elevation of an object. Such types of presentation are used with radar sets designed to help direct aircraft landings.

The timer ensures the smooth, efficient operation of a radar set. This device automatically turns other major parts of the radar set on and off at precisely the right time. The timer does so by sending control signals to the various parts of the system in the proper sequence.

The development of radar

The theories and experiments of many scientists led to the development of radar. James Clerk Maxwell, a British mathematician and physicist, made the first major contribution. During the 1860's, Maxwell said that there existed then-undiscovered kinds of electromagnetic waves that travel at the speed of light—299,792 kilometres per second. He also proposed that devices might be developed to generate such waves. In the late 1880's, Heinrich Hertz, a German physicist, proved Maxwell's ideas correct by producing radio waves. In addition, Hertz demonstrated that such electromagnetic waves could be reflected from solid objects.

Hertz's discovery promoted widespread efforts to find ways of using radio waves for communication. Some scientists realized that radio waves might also be used for detecting distant objects. However, little research could be done in this area until basic radio equipment was developed. Devices for sending and receiving radio signals over long distances became available by the early 1900's.

The first uses of radar. In 1925, two American physicists, Gregory Breit and Merle A. Tuve, bounced short radio pulses off the ionosphere. They determined the height of the ionosphere by measuring the time taken for the signals to return. Many scientists consider this experiment to have been the first practical use of radar. The success of the experiment encouraged researchers in many countries to conduct further scientific studies of the ionosphere with similar radar equipment and techniques.

Scientists also began experimenting with radio echoes to detect aeroplanes and ships. Much early work in this area was done by Robert Watson-Watt, a Scottish engineer and physicist. In 1935, he and a team of British scientists refined the pulse techniques used in ionospheric studies to locate aircraft at distances up to about 27 kilometres. During this time, researchers in France, Germany, and the United States also developed experimental radars that could detect planes and ships within a limited range. These early radars were unreliable and lacked the sensitivity needed for many tasks. But they provided information useful for military and navigational purposes.

The growing threat of a world war stimulated efforts to improve radar technology during the late 1930's. Before World War II began in September 1939, the British had built a chain of radar stations along the east and south coasts of England for defence against air and sea attacks. By 1940, the United States was producing pulse-type radar for tracking planes and for controlling antiaircraft guns. Germany also had similar kinds of radar by about the same time. Japan and the Soviet Union developed radar-warning systems a few years later.

Advances during World War II. The radar sets available at the beginning of the war proved extremely valuable for military operations. As a result, scientists were urged to develop even better equipment.

American and British radar experts cooperated closely during the war. The British were working to improve a special kind of vacuum tube called the *magnetron.* By late 1939, their version of the magnetron could generate pulses of microwave energy at high enough power levels to be used in radar systems. In 1940, the British turned it over to the Americans for further development and manufacturing.

The magnetron contributed greatly to the development of modern radar. This vacuum tube generates *microwaves*—that is, short radio waves with frequencies of more than 1,000 MHz. These high-frequency waves can be concentrated into narrow beams without the use of a huge radar aerial. Microwaves thus made it possible to design radar units small enough for aircraft, patrol boats, and mobile ground stations.

Before the war ended in 1945, British and American researchers had also developed methods of making enemy radar less effective. The Germans developed similar countermeasures. In one widely used method, planes on bombing missions dropped countless numbers of metal foil strips called *chaff.* Each strip reflected radio signals like a radar target. The bombers filled the air with so many strips that enemy radar operators had difficulty recognizing echoes from the planes.

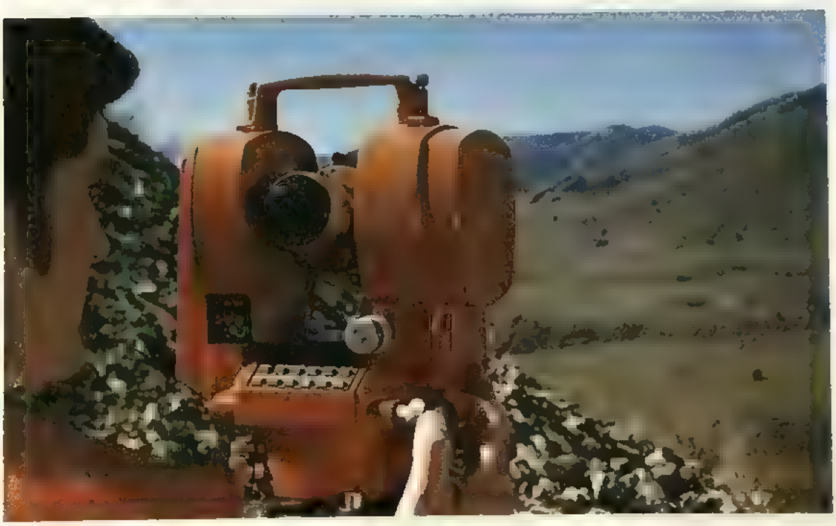
In another countermeasure, planes and ships carried high-powered radio transmitters. These transmitters produced enough interference to prevent enemy radar from detecting echoes from the planes and ships. Engineers also designed equipment that received pulses from enemy radar and sent them back at an increased power level after a short pause. As a result, false targets appeared on the display of the enemy radar.

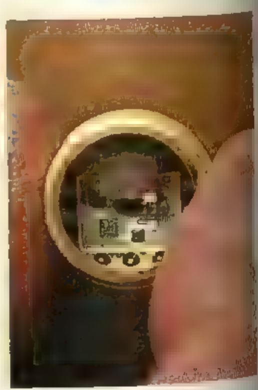
Continued progress. During the early 1950's, American scientists worked on a type of vacuum tube called the *klystron.* They succeeded in developing a high-powered klystron, which is well-suited for radars that require little variation in microwave frequency from one pulse to the next. Scientists later improved the klystron so that it could generate microwaves at extremely high power levels. This development helped increase the range of radar. Scientists also worked to improve radar sensitivity. By the late 1960's, they had designed receivers that produced little internal noise, which interferes with the reception of faint echoes.

The development of the electronic computer after World War II contributed much to radar technology. Computers make effective signal processors. They can analyse echoes at high speeds and present the information obtained in a form most useful to radar operators.

Radar also benefited from the invention of the transistor in 1947 and of related solid-state devices during the 1950's and 1960's. These devices enabled engineers to build lighter and more reliable radar sets. In addition, engineers used a solid-state device called a *phase shifter* to develop a new kind of radar. This radar, known as *phased array,* moves its signal beam electronically rather than by rotating an aerial. Phased array radars are especially useful in situations where the signal beam must be moved rapidly from one target to the next.

During the late 1960's, physicists perfected the laser. Their work resulted in the development of optical radars, which operate at the high frequencies of laser light. This type of radar requires an aerial only about





An optical radar is often used to survey rough terrain where distant points must be accurately measured between brush and large rocks, *above.* A tiny solid-state device called a *laser diode, above right,* enables this type of radar to transmit light waves in an extremely narrow beam.

the size of a drawing pin to send out an extremely narrow signal beam.

Radar in the future. Researchers today are seeking ways to reduce the size of microwave radars and to manufacture them at low cost. Pocket-sized radar units could be widely used as aids for blind people and as collision-warning devices in cars. Researchers have discovered that over-the-horizon radars can monitor weather over large areas of the ocean that could not be observed previously. These radars might be used to make weather predictions more accurate. In addition, microwave radars built into a single artificial satellite might one day track ship and aircraft traffic over most of the earth.

Related articles in *World Book* include:

Airport	Maxwell, James Clerk
DEW line	Navigation
Electronics	Radio
Guided missile	Rain (Measuring rainfall)
Hertz, Heinrich Rudolph	Range finder
Laser	Shoran
Microwave	Watson-Watt, Sir Robert A.

Outline

I. The uses of radar
- A. In aviation
- B. In ship navigation
- C. In the military
- D. In controlling traffic speed and flow
- E. In weather observation and forecasting
- F. In scientific research
- G. In space travel

II. How radar works
- A. Pulse radar
- B. Continuous-wave radar

III. The parts of a radar set
- A. The oscillator
- B. The modulator
- C. The transmitter
- D. The duplexer
- E. The aerial
- F. The receiver
- G. The signal processor
- H. The display
- I. The timer

IV. The development of radar

Questions

What are some uses of radar in scientific research?
Why was the magnetron important in the development of radar?
How does pulse radar find the distance to an object?
What is a Plan Position Indicator?
What are some military uses of radar?
What is the special feature of phased array radar?
How does radar help weather forecasters?
What is Doppler radar? How is it used?
Why is radar an effective aid in ship navigation?
What is a duplexer? Why is it important?

Radcliffe-Brown, A. R. (1881-1955), a British anthropologist, helped develop present-day American and British anthropological theories. Alfred Reginald Radcliffe-Brown was born in Birmingham, England and graduated from Cambridge University. After many years of research and teaching in London, Australia, and the Union of South Africa, he taught at the University of Chicago from 1931 to 1937. He then became the first professor of social anthropology at Oxford University.

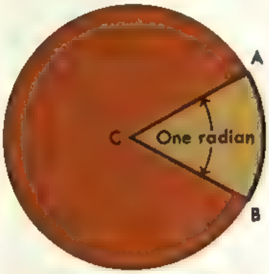
Radhakrishnan, Sarvepalli (1888-1975), was an Indian philosopher and statesman. He was regarded as a major interpreter of India's philosophical and religious traditions to the west. He was India's vice president from 1952 to 1962 and president from 1962 to 1967.

He was born in Tiruttani, Andhra Pradesh. His first important post in public office was as India's first ambassador to the Soviet Union. He served from 1949 to 1952.

Sarvepalli Radhakrishnan, *left,* was president of India when he met President Kennedy of the United States in 1963.

His most important political contribution was helping in the smooth transfer of power following the death of India's first prime minister, Jawaharlal Nehru, in 1964.

Radian is a metric unit used to measure angles. Engineers and scientists frequently measure angles in radians because the unit simplifies many of their calculations. Navigators, surveyors, and most other people measure angles in degrees. One radian equals an angle of 57.29578 degrees.



A radian. To draw an angle that equals 1 radian, first measure the radius of a circle. On the circumference of the circle, measure an arc that is the same length as the radius. In the diagram on the left, the arc AB equals the radius. Connect the ends of the arc with the centre of the circle. The angle between lines AC and BC equals 1 radian.

An angle of 1 radian is formed between two radii of a circle if they mark off an arc equal to the length of the radius of the circle. Circles and arcs may represent angles and may be measured in radians. For example, the circumference of a circle equals 2 times *pi* (π) times the radius of the circle. Thus, there are 2π radians in a circle.

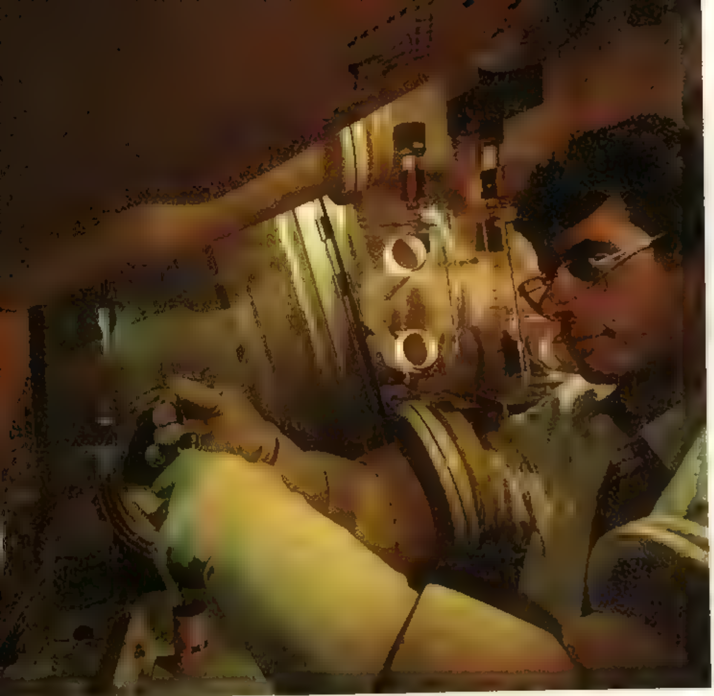
See also **Degree**.

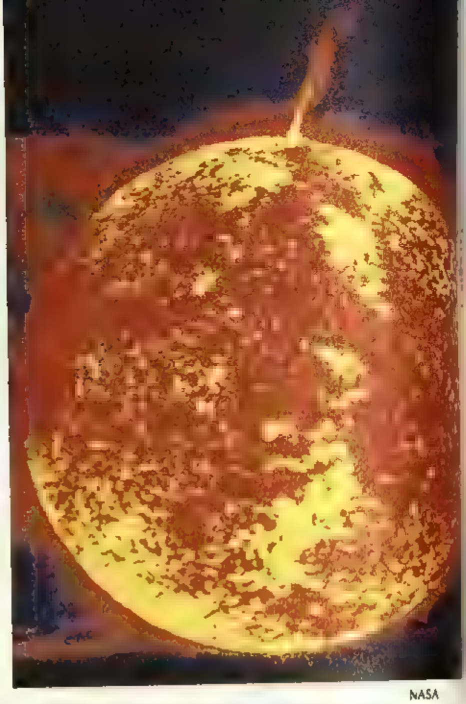
Radiant energy. See **Sun** (The sun's heat).

Radiant heating. See **Heating**.

Radiata pine is a conifer tree. It is also known as the Monterey pine. Native to California, U.S.A., the radiata pine has been successfully introduced into Australia, New Zealand, and South Africa. It is an important plantation tree because it grows and regenerates quickly. The tree grows to 25 to 30 metres high and has leaves that are 10 to 15 centimetres long.

Scientific classification. The radiata pine belongs to the pine family. It is *Pinus radiata*.


Philippe Plailly/SPL, Photo Researchers


NASA

Radiation is a vital form of energy. Artificially produced radiation has many uses in medicine and other fields. A medical worker handles radioactive iodine, *left,* with special gloves through a protective shield. All life on earth depends on natural radiation from the sun, *right.*

Radiation

Radiation is energy given off in the form of waves or small particles of matter. Radiation is found throughout the universe and comes in many forms. Most people have heard of X rays, gamma rays, and radiation from nuclear reactors. These types of radiation are often mentioned as possible health hazards, though X rays and gamma rays also have valuable uses in medicine. But there are many other forms of radiation.

The most familiar form of radiation is probably the light we see, such as the light from the sun or a flashlight. The sun's ultraviolet rays, which cause suntan and sunburn, are another form of radiation. Heat from a fireplace, radio signals bringing music, the intense light from a laser, and the microwaves used to cook food are still others.

Radiation is present whenever energy moves from one place to another. Atoms and molecules give off excess energy in the form of radiation. When the radiation strikes a substance, it may transfer some or all of its energy to the substance. Often, the energy takes the form of heat, increasing the temperature of the material. Except for light, most kinds of radiation are invisible.

There are two chief types of radiation. One type, called *electromagnetic radiation,* consists only of energy in the form of waves. The other type, known as *particle radiation* or *particulate radiation,* consists of tiny bits of matter.

There are many sources of electromagnetic radiation. All materials that have been heated act as sources of such radiation. The sun produces electromagnetic radiation from nuclear reactions in its core. This energy heats the sun's outer layer until the hot gases glow, giving off light and other radiation. This solar radiation travels through space to the earth and other planets.

Particle radiation comes from radioactive substances. Radium, uranium, and many other heavy elements found in rocks and soil are naturally radioactive. In addition, scientists can create radioactive forms of any element in a laboratory by bombarding the element with *subatomic particles,* the tiny bits of matter that make up atoms.

All life on earth depends on radiation, but some forms of radiation can be dangerous if not handled properly. X rays, for example, allow doctors to locate and diagnose hidden diseases. But X rays can also damage living cells, causing them to become cancerous or die. Light from the sun enables plants to grow and warms the earth, but it also causes sunburn and skin cancer. Gamma radiation is used to treat disease by killing cancer cells, but it can also cause birth defects. Nuclear power plants produce electric energy, but the same facilities create radioactive waste that can kill living things.

Uses of radiation

In medicine, radiation and radioactive substances are used for diagnosis, treatment, and research. X rays, for example, pass through muscles and other soft tissue but are stopped by dense materials. This property of X rays enables doctors to find broken bones and to locate cancers that might be growing in the body. Doctors also find certain diseases by injecting a radioactive substance and monitoring the radiation given off as the substance moves through the body.

In communication. All modern communication sys-

tems use forms of electromagnetic radiation. Variations in the intensity of the radiation represent changes in the sound, pictures, or other information being transmitted. For example, a human voice can be sent as a radio wave or microwave by making the wave vary to correspond to variations in the voice.

In science, researchers use radioactive atoms to determine the age of materials that were once part of a living organism. The age of such materials can be estimated by measuring the amount of radioactive carbon they contain, in a process called *radiocarbon dating.* Environmental scientists use radioactive atoms known as *tracer atoms* to identify the pathways taken by pollutants through the environment.

Radiation is used to determine the composition of materials in a process called *neutron activation analysis.* In this process, scientists bombard a sample of a substance with particles called *neutrons.* Some of the atoms in the sample absorb neutrons and become radioactive. The scientists can identify the elements in the sample by studying the radiation given off.

In industry, radiation has many uses. Food processing plants employ low doses of radiation to kill bacteria on certain foods, thus preserving the food. Radiation is used to make plastics because it causes molecules to link together and harden. Industry also uses radiation to look for flaws in manufactured materials in a process called *industrial radiography.*

Nuclear power plants obtain energy from *nuclear fission,* the splitting of the nucleus of an atom into the nuclei of two lighter elements. Fission releases large amounts of radiation, including infrared radiation that is used to turn water into steam. This steam then runs a turbine that produces electric energy.

The opposite process, *nuclear fusion,* occurs when the nuclei of two lighter elements join to form the nucleus of a heavier one. Fusion, like fission, releases vast amounts of radiation. Fusion creates the heat and light of the sun and other stars, and the explosive force of the hydrogen bomb. Scientists are investigating methods of harnessing fusion to produce electric energy (see **Nuclear energy** [Experimental fusion devices]).

In military operations, radio waves are used in radar systems to locate aircraft and ships. Microwaves and the light from lasers have been used both for communication and to guide "smart" missiles to their targets. Heat-sensing devices for night detection rely on the infrared radiation given off by living bodies.

Radiation and radioactivity

Scientists distinguish radiation from *radioactivity,* which is a property of some types of matter. Radioactivity causes matter to release certain forms of radiation as the result of changes in the nuclei of the atoms that make up the matter.

To understand radiation and radioactivity, it is necessary to understand the structure of an atom and how it can change. An atom consists of tiny particles of negative electric charge called *electrons* surrounding a heavy, positively charged nucleus. Opposite electric charges attract each other, and like charges *repel* (push away) each other. The positively charged nucleus therefore attracts the negatively charged electrons and so keeps them within the atom.

The nucleus of every element except the most common form of hydrogen consists of particles called *protons* and *neutrons.* (A normal hydrogen nucleus is made up of a single proton and no neutrons.) Protons carry a positive charge, and neutrons have no charge. The most common form of helium, for example, has two protons and two neutrons in the nucleus and two electrons outside the nucleus. Protons and neutrons consist of even smaller particles called *quarks.*

Within the nucleus, the positively charged protons repel one another because they have like charges. The protons and neutrons remain together in the nucleus only because an extremely powerful force holds them together. This force is called the *strong nuclear force* or the *strong interaction.* See **Atom** (Forces in the nucleus).

An atom can change the number of protons and neutrons in its nucleus by giving off or taking in atomic particles or bursts of energy—that is, by giving off or taking in radiation. But any change in the number of protons in the nucleus produces an atom of a different element. Radioactive atoms spontaneously release radiation to take on a more stable form. The process of giving off atomic particles is called *radioactive decay.* As radioactive elements decay, they change into different forms of the same element or into other elements until they finally become stable and nonradioactive.

Radioactive decay takes place at different rates in different elements or different forms of the same element. The rate of decay is measured by the *half-life,* the length of time needed for half the atoms in a sample to decay. For example, the half-life of caesium 137, a radioactive form of the metal caesium, is about 30 years. After about 60 years, approximately a quarter of the original caesium 137 remains. After another 30 years, only an eighth remains, and so on. The half-life of radon 222 is about 3.8 days. Half-lives vary from fractions of a second to billions of years.

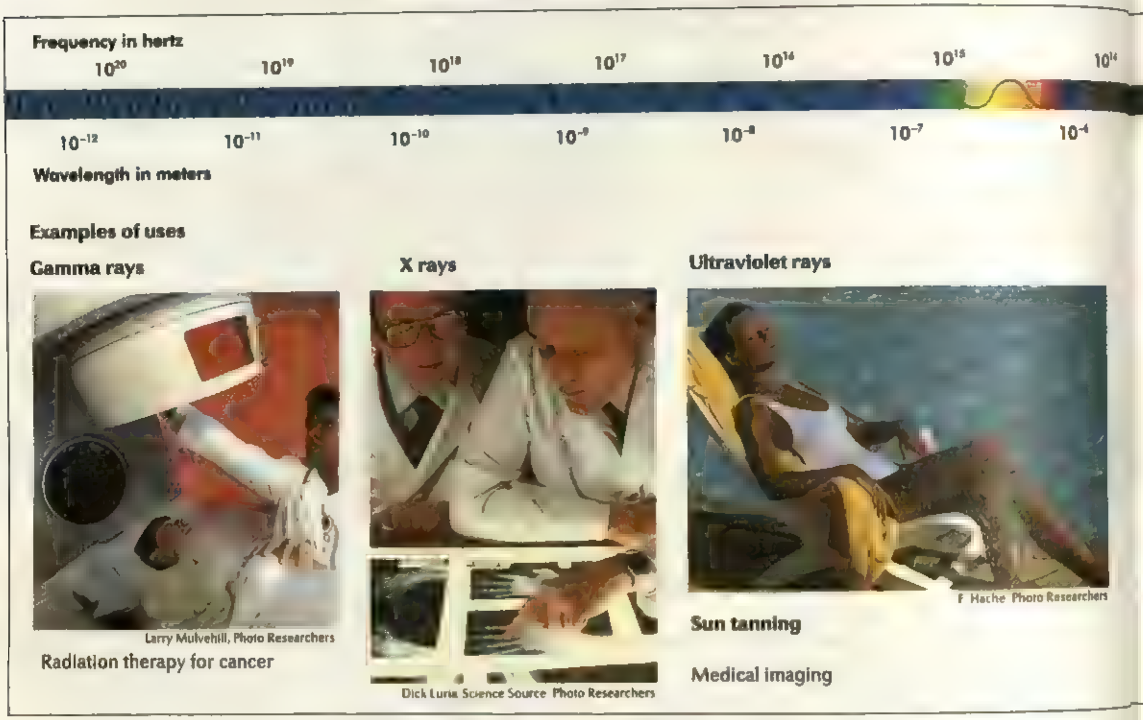
Electromagnetic radiation

Electromagnetic radiation consists of electric and magnetic energy. Every electrically charged body is surrounded by an *electric field,* a region where the body's electric force can be felt. Every magnetic body is surrounded by a similar region known as a *magnetic field.* An electric current or a changing electric field creates a magnetic field, and a changing magnetic field creates an electric field. Electric and magnetic fields act together to produce electromagnetic radiation.

Electromagnetic radiation moves through space as a wave, but it also has properties of particles. Atoms release electromagnetic radiation in the form of a tiny packet of energy called a *photon.* Like a particle, a photon occupies a fixed amount of space. Like waves, however, photons have a definite frequency and wavelength, which can be measured. The number of times each second that a wave passes through one cycle is called its *frequency.* The distance a wave travels in the time it takes to pass through one cycle is called the *wavelength.* The energy of a photon of electromagnetic radiation varies according to the frequency and wavelength. If the radiation has a high frequency and a short wavelength, its photons have high energy. If the radiation has a low frequency and a long wavelength, its photons have low energy.

Kinds of electromagnetic radiation

Electromagnetic radiation travels through space in waves, which vary in *frequency* (how quickly a wave passes through a cycle) and *wavelength* (how far the wave travels during one cycle). The kinds of radiation range in wavelength from short gamma rays to long radio waves.



Radiation therapy for cancer

Medical imaging

Sun tanning

In a vacuum, all electromagnetic radiation moves at the speed of light—299,792 kilometres per second. The various kinds of radiation differ, however, in their frequency and wavelength. They are classified according to an arrangement called the *electromagnetic spectrum.* In order of increasing wavelength, the kinds of electromagnetic radiation are gamma rays, X rays, ultraviolet rays, visible light, infrared rays, microwaves, and radio waves. Gamma rays and X rays are high-energy forms of radiation. Radio waves, on the other end of the spectrum, have relatively low energy.

Particle radiation

Particle radiation consists of protons, neutrons, and electrons, the tiny particles that are the building blocks of an atom. All types of particle radiation have both mass and energy. Most such radiation travels at high speeds but slower than the speed of light. A type of particle called a *neutrino,* however, has an unmeasurable mass and travels at or near the speed of light.

Scientists have discovered that protons, neutrons, and electrons, which we usually think of as particles, also behave like waves. These waves, called *matter waves,* have wavelengths. The faster a particle is moving, the shorter its wavelength. This means that particle radiation, like electromagnetic radiation, has characteristics of both particles and waves. There are four common types of particle radiation: (1) alpha particles, (2) beta particles, (3) protons, and (4) neutrons.

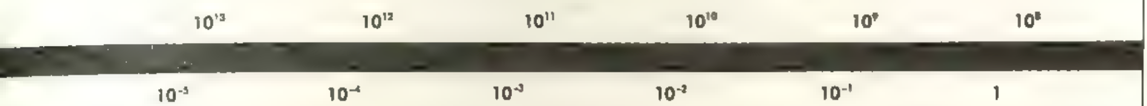
Alpha particles consist of two protons and two neutrons and are identical with the nuclei of helium atoms. Alpha particles have a positive electric charge and a mass about 7,300 times larger than the mass of an electron. Alpha particles are given off by the nuclei of some radioactive atoms. Most alpha particles eventually gain two electrons and become atoms of helium gas.

Beta particles are electrons. Most beta particles are produced when a radioactive atom undergoes a nuclear transformation. In the process, a neutron in the atom's nucleus changes into a proton and a beta particle is released.

Most beta particles are negatively charged, but some are positively charged particles called *positrons* produced when a proton changes into a neutron. Positrons are a form of *antimatter,* matter that resembles ordinary matter except that its electric charge is reversed. When a positron collides with a negatively charged electron, the two particles destroy each other, and two or three gamma-ray photons are produced.

Two other small particles, *neutrinos* and *antineutrinos,* accompany beta radiation. When a nucleus produces a positron, it also releases a neutrino, which has no charge and an undetermined mass. When a nucleus creates and releases a negatively charged beta particle, it also gives off an antineutrino, the antimatter form of a neutrino.

Protons and neutrons can also be released from some radioactive nuclei. Each has a mass about 1,850 times larger than the mass of an electron. The mass of a neutron is slightly larger than the mass of a proton. Neutron radiation is more common than proton radiation, which rarely is produced naturally on earth.



Infrared rays

Aaron Haupt, Frazier Photolibrary

Heating and cooking

Microwaves

H. Gans, The Image Works

Microwave cooking

Radio waves

David R. Frazier

Television broadcasting

WORLD BOOK illustrations by Hans & Cassady, Inc.

Sources of radiation

Natural sources of radiation include the sun and other stars, and naturally radioactive elements. There are also many artificial sources of radiation.

The sun and other stars give off both electromagnetic and particle radiation. This radiation results from the fusion of hydrogen nuclei in the star. The hydrogen changes into helium and releases a large amount of energy, producing electromagnetic radiation across the entire spectrum. Besides visible light, a star gives off everything from radio waves to high-energy gamma radiation. However, the gamma radiation, which is produced when new elements form deep in the core of the star, does not reach earth directly.

Stars also produce alpha and beta particles, protons, neutrons, and other forms of radiation. The high-energy particles released by stars are called *cosmic rays.* Even the sun puts on brief displays called *solar flares,* bathing the earth in cosmic rays strong enough to interfere with communications.

Naturally radioactive substances. Most naturally radioactive substances belong to one of three sequences of change called *radioactive decay series:* (1) the uranium series, (2) the thorium series, and (3) the actinium series. In each of these series, heavy *isotopes* (forms of the same element that have different numbers of neutrons) decay into various lighter isotopes by giving off radiation until they eventually become stable.

The uranium series begins with uranium 238, the heaviest isotope of uranium, which has 92 protons and 146 neutrons. After losing an alpha particle, which consists of 2 protons and 2 neutrons, the nucleus has 90 protons and 144 neutrons. It is no longer uranium but a radioactive isotope of thorium. Scientists call this process of changing into another element *transmutation.* The thorium, in turn, breaks down in several steps to radium 226. The radium 226 decays into radon, a naturally occurring radioactive gas. Radon may become a health hazard if it accumulates in certain buildings, especially poorly ventilated ones. The series continues until the isotope becomes a stable form of lead.

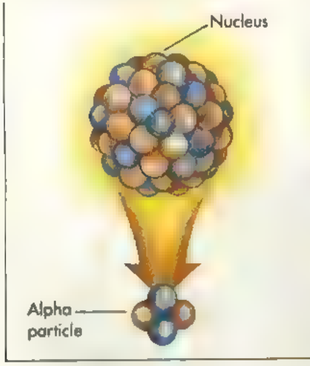
The thorium series begins with thorium 232, an isotope of thorium. The actinium series begins with uranium 235, also called U-235, another isotope of uranium. These two series also end with lead.

A fourth group of naturally radioactive substances includes a wide variety of materials that do not belong to a radioactive series. Many of these elements, including carbon 14, potassium 40, and samarium 146, are produced by cosmic radiation striking the earth's atmosphere. Carbon 14 and potassium 40 are also present in the human body.

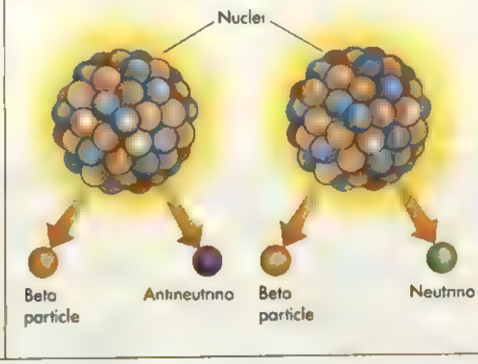
Artificial radioactive substances are made by human activities, such as the fission that takes place in nuclear weapons and nuclear reactors, or in laboratories. When fission splits a nucleus, it releases several types of radiation, including neutrons, gamma radiation, and beta particles. Fission also produces new radioactive atoms called *fission products.* For example, atomic bomb tests in the 1950's and 1960's covered the earth with a fission product called caesium 137, a radioactive

Particles given off by radioactive atoms

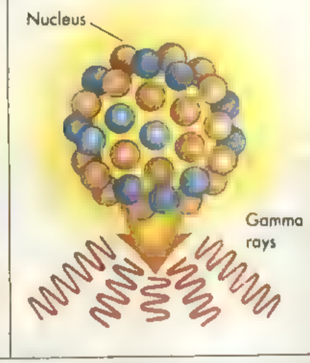
Alpha particles consist of two protons and two neutrons that act as one particle. When the nucleus of a radioactive atom emits an alpha particle, it thus loses two protons and two neutrons.



Beta particles are high-speed electrons emitted from the nuclei of certain radioactive elements. Beta particles can be either negative or positive. When a nucleus emits a negative charged beta particle, it also gives off an antineutrino. When a nucleus emits a positively charged beta particle, called a *positron,* it also gives off a neutron.



Gamma rays are particles of electromagentic energy called *photons.* Gamma rays are released when a nucleus, after radioactive decay, is in a high-energy state. The rays travel at the speed of light.



WORLD BOOK illustration by Sarah Woodward

isotope of caesium. Used fuel from nuclear power plants also contains many fission products, such as plutonium 239, strontium 90, and barium 140. This used fuel, called nuclear waste, remains radioactive and dangerous for thousands of years.

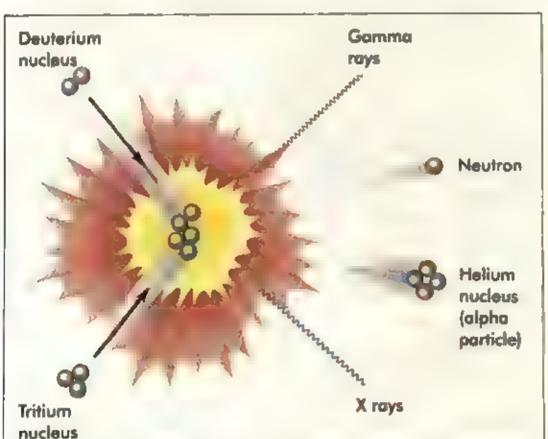
In addition, nuclear plants create new radioactive elements known as *activation products.* Activation products form when the pipes and other materials in a nuclear reactor absorb neutrons and other types of radiation, becoming radioactive.

Many other types of radiation are created by human activities. Physicists use powerful devices called *particle accelerators* to speed up the movement of electrically charged particles, including electrons, protons, and entire nuclei. The physicists then bombard stable, nonradioactive atoms with beams of these high-speed particles. The resulting collisions produce new radioactive atoms and help scientists learn more about the structure and properties of atoms.

Causes of radiation

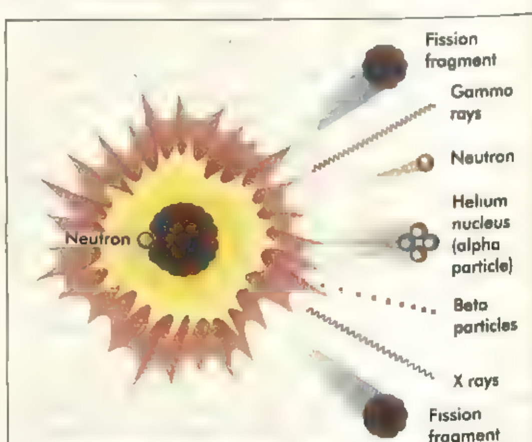
Within an atom, electrons are confined to regions called *electron shells* surrounding the nucleus according to how much energy they have. Electrons with less energy travel in inner shells, and those with more energy are in outer shells. Protons and neutrons in the nucleus are also arranged according to their energy levels in layers known as *nuclear shells.* All the protons, neutrons, or electrons in a shell have almost the same amount of energy.

Just as water always seeks its lowest possible level, electrons seek the state of lowest energy. When an electron shifts from an outer shell to one closer to the nucleus, the electron releases a packet of energy called a



WORLD BOOK illustration by Mark Swindle

Nuclear fusion releases large amounts of radiation. Fusion occurs when the nuclei of two lightweight elements join to form the nucleus of a heavier one. In the example above, nuclei of deuterium and tritium unite and form a helium nucleus.



WORLD BOOK illustration by Mark Swindle

Nuclear fission releases several types of radiation, including neutrons, alpha and beta particles, gamma rays, and X rays. Fission involves using a neutron to split a nucleus of a heavy element, such as uranium, into two fission fragments.

photon, which escapes from the atom. The energy of the photon equals the difference in the electron's energy as it jumps from the original shell to the new one. If the energy difference is small, the atom will give off visible light, infrared radiation, or both. If the difference is large, the atom might produce X rays.

When a proton or neutron moves from one nuclear shell to another, the nucleus releases gamma radiation. Most atoms that release particle radiation in the course of radioactive decay also produce gamma radiation because their protons and neutrons are shifting into new shells. The radiation produced by nuclear reactions also results from protons, neutrons, and electrons moving to new shells. In nuclear fission, for example, the particles are moving to the shells of new nuclei created when a nucleus splits into two smaller nuclei.

Electromagnetic radiation is also produced if an electrically charged particle changes direction, speed, or both. A particle that enters an electric or magnetic field, for example, slows down and changes course. As a result, the particle releases radiation. X rays are produced whenever electrons suddenly decelerate, as in the case when they collide with atoms of metal to create the X rays in an X-ray machine. Electrons also produce X rays if they pass near a large nucleus. The negatively charged electrons are attracted by the positively charged nucleus. As the electrons change direction, they produce X rays. X rays produced in this way are called *bremsstrahlung,* a German word that means *braking radiation.*

Effects of radiation

Radiation produces two main effects in atoms or molecules: (1) excitation and (2) ionization.

In *excitation,* an atom or molecule absorbs energy from radiation. Its electrons move to higher-energy shells. In most cases, the excited atom can hold the extra energy for only a fraction of a second before it releases the energy as a photon and falls back to a state of lower energy. In *ionization,* the radiation transfers enough energy to the electrons in an atom that they leave the atom and move through space. Atoms that have lost electrons become positively charged particles called *positive ions.* The electrons knocked loose may then join other atoms.

Excitation and ionization also affect living tissues. The body's cells contain molecules, many of which are held together by electrons. When radiation either excites or ionizes the molecules in cells, chemical bonds may be broken and the shape of a molecule may be changed. These changes disrupt the normal chemical processes of the cells, causing the cells to become abnormal or die.

If radiation affects molecules of DNA (deoxyribonucleic acid), the hereditary material in living cells, it may cause a permanent change called a *mutation.* In rare cases, mutations caused by radiation may pass on undesirable traits to offspring. Even low-energy photons, particularly ultraviolet light from the sun, may produce damage by excitation. If the damage to an organism's genetic material is severe, the cell becomes cancerous or dies while trying to divide. The effect produced depends on the radiation's ionizing ability, the dose received, and the type of tissue involved.

Ionizing ability. Radiation may be classified as *ionizing* or *non-ionizing.* Ionizing radiation is the most dangerous. Some types of ionizing radiation have enough energy to directly strip electrons from any atoms near their path. Such radiation includes alpha and beta particles and protons. Other types of ionizing radiation, including X rays, gamma radiation, and neutron radiation, must first transfer energy to an atom. The added energy then causes the atom to lose an electron.

Non-ionizing radiation consists of photons with too little energy to cause ionization. Radio waves, microwaves, infrared radiation, and visible light are all non-ionizing radiation. Each will cause only excitation.

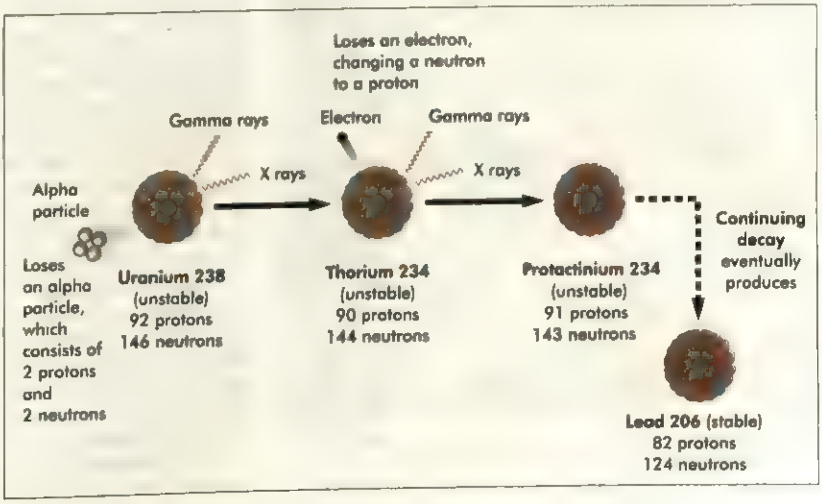
Dose. Scientists use two systems for measuring the amount, or *dose,* of radiation absorbed by a substance. The older system, still commonly used, measures doses in units called *rads. Rad* stands for *r*adiation *a*bsorbed *d*ose. A rad is defined as a dose of $\frac{1}{100}$ *joule* of radiation energy per kilogram of material (see **Joule**.) The newer system, introduced in 1975, measures dosage in units called *grays,* named after Louis Gray, an English radiation biologist. One gray is equal to 100 rads or 1 joule per kilogram of material.

Different types of radiation produce different effects

WORLD BOOK illustration by Mark Swindle

Radioactive decay

A radioactive decay series is the process by which a radioactive atom releases radiation and changes into different forms of the same element or into other elements. The uranium series, shown on the right, begins with uranium 238. Losing an alpha particle, the atom changes into radioactive thorium 234. The series continues through many more steps of decay until the atom becomes a stable form of lead.



at the same dose. To account for this, scientists have developed the *quality factor.* The quality factor indicates how much the radiation damages living tissue compared with an equal dose of X rays. For example, a dose of alpha particles causes about 10 times as much damage as the same dose of X rays, so alpha particles have a quality factor of 10. X rays, gamma radiation, and beta particles have a factor of 1, while neutrons have factors that range from 2 to 11.

Multiplying the dose by the quality factor gives a measure of damage called the *dose equivalent.* If the dose is given in rads, the dose equivalent will be in *rems.* A rem, which stands for *r*oentgen *e*quivalent in *m*an, is the amount of radiation necessary to cause the same effect on a human being as 1 rad of X rays. If the dose is reported in grays, the dose equivalent will be in *sieverts,* named after Swedish radiologist Rolf Sievert.

Large doses cause a combination of effects called *radiation sickness.* Doses above 100 rems damage red and white blood cells. This damage is known as the *haematopoietic effect.* At doses above 300 rems, death may follow in several weeks. Above 1,000 rems, the cells lining the digestive tract die and bacteria from the intestines invade the bloodstream. This effect, known as the *gastrointestinal effect,* may lead to death from infection within a week. At doses of several thousand rems, the brain is injured and death can come within hours.

Deaths from radiation sickness are extremely rare. People have only suffered such large doses in reactor accidents, in a few cases where radioactive material was mishandled, and in the 1945 bombings of Hiroshima and Nagasaki, Japan, during World War II. The worst reactor accident in history was a 1986 explosion and fire at the Chernobyl nuclear power plant in Ukraine, then part of the Soviet Union. Thirty-one workers died.

Small doses. The doses received in daily life, sometimes called *background doses,* are much smaller. Scientists estimate that the average background dose is 0.3 to 0.4 rem per year. About half of this amount comes from breathing radon gas released by radioactive rocks and soil. Medical and dental X rays add another 0.04 rem per year. Other sources, such as nuclear power plants and waste disposal sites, typically account for less than 0.01 rem per year. Smokers take in much higher doses from radioactive isotopes in smoke.

Robert Gale, Sygma

The worst radiation accident in history was a 1986 explosion and fire at the Chernobyl plant in Ukraine. Hundreds of workers suffered radiation sickness, *above,* and 31 died.

An accumulation of small doses of radiation increases the risk of developing a condition, but not the severity of the condition. The chief effects of repeated small doses of radiation are cancer and birth defects.

To protect people from the effects of radiation, the International Commission on Radiological Protection, a panel of experts from many countries, sets guidelines for exposure. This group recommends that nuclear workers receive a maximum permissible dose (MPD) of no more than 5 rems per year. The commission also urges that the general public receive no more than 0.5 rem in any year. Other agencies set similar guidelines. Such agencies include the Australian Nuclear Science and Technology Organization; the Bhabha Atomic Research Centre, India; the Council for Nuclear Safety, South Africa; and the National Radiological Protection Board, United Kingdom.

History

Early theories and discoveries. Scientists have studied radiation since ancient times. In the 300's and 200's B.C., the Greek philosopher Epicurus wrote of particles "streaming off" from the surface of bodies. Euclid, a Greek mathematician of the same time, thought the eye sent out radiation to allow an object to be seen.

Robert Grosseteste, an English bishop and scholar of the 1200's, thought of light as the root of all knowledge. He believed that understanding the laws controlling light would uncover all the laws of nature.

The composition of light was debated in the 1600's by the followers of the English scientist Sir Isaac Newton and the Dutch physicist Christiaan Huygens. Newton insisted that light consisted of tiny particles, while Huygens suggested it was composed of waves. Scientists argued about these two theories for more than 100 years. Then, in the early 1800's, the British physicist Thomas Young showed that light had properties similar to those of sound and water waves. A few years later, the French physicist Augustin Fresnel provided more evidence. By 1850, most scientists accepted Young's and Fresnel's findings as proof of the wave nature of light.

In 1864, the British scientist James Clerk Maxwell suggested that light consisted of electromagnetic waves. Maxwell also predicted that other, invisible forms of electromagnetic radiation would be discovered. Maxwell's predictions were verified by the work of two German physicists, Heinrich Hertz and Wilhelm Roentgen. Hertz discovered radio waves in the late 1880's, and Roentgen discovered X rays in 1895.

Discovery of radioactivity. In 1896, the French physicist Antoine Henri Becquerel discovered that crystals of a uranium compound would darken photographic plates even if the plates were not exposed to light. He proposed that uranium gave off energy in the form of radiation. Later experiments by the British physicist Ernest Rutherford showed that this radiation consisted of particles he named *alphas* and *betas.*

In 1898, the French physicists Marie and Pierre Curie found other substances that produced radiation, naming them *polonium* and *radium.* A few years later, Rutherford showed that radioactive substances could change into new elements in the process of transmutation.

The work of Rutherford and the Curies led to great interest in the structure of the atom. Rutherford, his colleagues, and other scientists soon proved that the atom had a nucleus of high mass and positive electric charge surrounded by negatively charged electrons.

The quantum theory. In 1900, the German physicist Max Planck studied radiation from hot objects. He suggested that objects could only emit and absorb this radiation in packets of energy called *quanta,* a name later changed to *photons.* Another German physicist, Albert Einstein, used Planck's theory in 1905 to explain a phenomenon known as the *photoelectric effect.* Earlier scientists had discovered this effect, in which a bright beam of light striking a metal causes the metal to release electrons. Einstein proposed that the energy supplied by a single photon could free an electron from an atom in the metal. To produce the photoelectric effect, photons act in a localized manner characteristic of particles rather than waves. Thus, Einstein's ideas revived the particle theory of light. Scientists now know that radiation has features of both particles and waves. Both types of features can be observed, but not in the same experiment. If scientists set up an experiment to investigate the photoelectric effect, the photons behave as individual particles. But if a stream of particles is passed through a narrow slit, the photons exhibit the behaviour of continuous electromagnetic waves.

The Danish physicist Niels Bohr used the quantum theory in 1913 to explain the structure of the hydrogen atom. Bohr proposed that electrons can have only certain values of energy. He showed that atoms release photons of radiation when their electrons drop from a high-energy level to a lower one. In 1924, the French physicist Louis de Broglie predicted that electrons themselves might act as waves, called matter waves.

The nuclear age began in 1942, when Italian-born physicist Enrico Fermi and his co-workers in the United States produced the first artificial nuclear chain reaction. Since then, many scientists have turned their attention to finding uses for radioactivity and radiation. Nuclear weapons based on fission—the atomic bomb—and fusion—the hydrogen bomb—were developed. The first full-scale nuclear power plant began operation in 1956. Radiation from across the entire electromagnetic spectrum was harnessed for communication, medicine, industry, and research.

In the 1960's and 1970's the field of *health physics* grew rapidly. Health physics is the branch of science that deals with the protection of people against harmful radiation. The science also studies the use of radiation for human benefit.

Since the late 1970's, several studies have indicated that repeated exposure to low doses of ionizing radiation could cause serious health problems. As a result of these findings, many people are demanding strict regulation of the production and use of high-energy radiation. Scientists are conducting further studies to determine the effects of low levels of radiation on people and on the environment.

Related articles in *World Book* include:

Kinds of radiation

Alpha particle
Beta particle
Cosmic rays
Electromagnetic waves
Gamma rays
Infrared rays
Light (The nature of light)
Microwave
Radio (How radio works)
Sun (Solar radiation)
Ultraviolet rays
X rays

Radioactive substances

Actinium
Americium
Astatine
Berkelium
Californium
Curium
Einsteinium
Element 104
Element 105
Element 106
Element 107
Element 108
Element 109
Element 110
Element 111
Fermium
Francium
Lawrencium
Mendelevium
Neptunium
Nobelium
Pitchblende
Plutonium
Polonium
Promethium
Protactinium
Radiocarbon
Radium
Radon
Technetium
Thorium
Transuranium element
U-235
Uranium

Other related articles

Atom
Cancer (Carcinogens; Radiation therapy)
Energy
Environmental pollution (Hazardous waste)
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Nuclear energy
Nuclear physics
Nuclear weapon
Particle accelerator
Particle detector
Particle physics
Phosphorescence
Photon
Plasma (physics)
Quantum electrodynamics
Quantum mechanics
Radiochemistry
Radiogeology
Radiology
Transmutation of elements

Outline

Questions

What is radioactivity?
How does ionizing radiation damage living cells?
What is the final product of uranium decay?
How are positive ions produced?
What are some natural sources of radiation?
How do physicists create radioactive forms of elements?
Who first suggested that radiation came in packets of energy called *quanta* or *photons*?
Why do atoms give off gamma radiation?
What are the chief health risks caused by repeated low doses of radiation?
What is the difference between electromagnetic radiation and particle radiation?
What are the chief types of electromagnetic radiation?

Radiation belt. See Van Allen belts.

Radiation sickness is the term for a variety of symptoms that follow a person's exposure to damaging amounts of certain types of radiation. The radiation may come from nuclear explosions and the resulting fallout, from medical and industrial uses of radioisotopes, or from particle accelerators or X-ray machines. Ionization from the radiation causes a series of reactions in tissue that results in damage to the body's cells (see **Radiation** [The effects of radiation]; **Fallout**).

Some types of cells are more easily injured by radiation than others. The most sensitive cells are those undergoing rapid replacement: those of the blood-forming bone marrow and lymphoid tissues, intestines, skin, and those of a human embryo. Adult muscle and brain cells are the least sensitive to radiation.

Scientists use a unit called the *rem* as a measure of radiation exposure. Over a lifetime, a person typically receives 7 to 14 rems from natural sources of radiation, such as cosmic rays. A single exposure of 5 to 75 rems produces few observable symptoms. Vomiting, fatigue, and loss of appetite accompany exposures of 75 to 200 rems, and recovery takes a few weeks. Severe changes in blood cells and haemorrhage occur with exposures of more than 300 rems. Above 600 rems, additional symptoms include loss of hair and loss of the body's ability to fight infection, usually resulting in death.

Doctors treat the symptoms of radiation sickness with blood transfusions and antibiotics to fight infection. Survivors of radiation sickness may experience long term, indirect effects. These include reduced life-expectancy, proneness to certain cancers, and lowered resistance to infection and anaemia.

Radiator is a set of pipes or tubes that gives off heat to its surroundings. Steam or hot-water radiators in homes transfer heat to the air in a room. When warmed, the air next to the pipes expands, becomes lighter, and rises. Cooler air from the room streams in to take its place, creating a constant circulation of air. This process is called *convection,* and certain types of radiators are called *convectors.* Radiators also heat room air by direct *radiation.* See **Heat** (How heat travels).

A car radiator works in the same way. Water carries heat from the engine to tubes at the front of the radiator. Air rushing past the tubes absorbs heat from the water and cools it. An engine-driven or electric fan helps move air through the radiator when the car is stopped or moving at low speed.

See also **Car** (diagram: The major systems of a car [Cooling system]); **Heating** (Central heating systems).

Radical, in chemistry, is a group of two or more charged or neutral atoms that have at least one unpaired electron. Molecular oxygen, O_2, has two unpaired electrons and is a common radical. Most radicals are extremely reactive and combine with other atoms or radicals to form compounds or ions. However, some radicals, called *free radicals,* may exist for relatively short times unbound to any other group. Radicals play a major role in certain chemical reactions of commercial significance, including the formation of polymers.

Radicalism is a political philosophy that emphasizes the need to find and eliminate the basic injustices of society. The word *radicalism* comes from the Latin word *radix,* meaning *root.* Radicals seek what they consider the roots of the economic, political, and social wrongs of society and demand immediate and sweeping changes to wipe them out.

In Europe, the term *radical* came into general use in Great Britain during the early 1800's. It described reform demands by such political leaders as Charles James Fox. In 1797, Fox had demanded what he called "radical reform" to make Britain's political system more democratic. During the 1800's, the British philosopher Jeremy Bentham led a group called "philosophical radicals." He believed all legislation should aim to provide the greatest happiness for the greatest number of people. See **Bentham, Jeremy; Fox, Charles.**

Radicalism developed in France after the French Revolution (1789-1799) had made that nation a republic. During the 1800's, many European radicals took the French Revolution as their model and tried to establish republics in their own countries.

Several European radicals established the socialist movement and demanded the total reconstruction of society. During the late 1800's, the movement split into moderate and radical factions. The moderate socialists sought change through gradual reform. The radical socialists insisted that only revolution could reform society. In Russia, the moderates were called *Mensheviks* and the radicals *Bolsheviks.* The Bolsheviks seized power in 1917 and set up a Communist government.

In India, the nationalist movement was also divided. Although large numbers of people wanted to expel the British from India they were unable to agree on how to bring about the change. Moderates followed the Mahatma (Mohandas Gandhi) in a campaign of civil disobedience (see **Gandhi, Mohandas**). The more radical nationalist movement saw Britain as an enemy which could be defeated only by violence. During World War II (1939-1945) Subhash Chandra Bose, leader of the radical faction, began negotiations with Nazi Germany. He then raised an Indian army to fight alongside the Japanese, and drive the British out of India (see **Bose, Subhash Chandra**). This force was defeated. When the war ended, British officials met with moderate nationalist leaders. India gained independence in 1947.

In the United States, the followers of Alexander Hamilton, the first secretary of the treasury, opposed the French Revolution. They used the term *radicals* for the pro-French followers of Thomas Jefferson.

In the years before and during the Civil War (1861-1865), radical abolitionists called for an immediate end to slavery. Other radicals demanded cheap land, prohibition of alcoholic beverages, voting reforms, and women's rights.

American radicals, unlike European radicals, have never been able to establish a major political party. However, radicals in the United States have influenced national politics through their writings and speeches.

During the 1960's and early 1970's, supporters of "black power" condemned the civil rights movement on the ground that its goals and tactics were too moderate. During the 1970's and 1980's, radical feminists urged the overthrow of male-dominated institutions. The moderates sought equal pay for equal work, passage of an Equal Rights Amendment, and federal support for daycare centres.

See also **Left wing; Right wing.**

Radio broadcasting originates in a studio and can be heard almost anywhere. A disc jockey at a radio station, *above left,* announces and plays recorded music. Many people use small, lightweight portable radios, *above right,* to receive broadcasts.

Radio

Radio is one of our most important means of communication. It enables people to send words, music, codes, and other signals to any part of the world. People on ships and in aircraft can keep in contact with people on land by using radio. People also use radio to communicate far into space.

The most widespread and familiar use of radio is broadcasting. Radio broadcasts feature music, news, discussions, interviews, descriptions of sports events, drama, reviews of cultural events, religious programmes, and advertising. People wake up to clock radios and drive to their jobs listening to car radios. They also listen to their favourite radio programmes in their leisure time.

Radio broadcasting once had much the same entertainment role as television has today. From the 1920's to the early 1950's, millions of families in America, Australia, and Europe gathered around their radios every night. They listened to dramas, light comedies, variety shows, live music, and other kinds of programmes. This period, which is sometimes called the *golden age of radio,* ended in most Western nations with the rise of television during the 1950's.

Radio has many uses in addition to broadcasting. Aeroplane pilots, astronauts, construction workers, police officers, farmers, sailors, soldiers, taxicab drivers, and others use radio for quick communication. Scientists send radio waves into the sky to learn about the weather. Telephone and telegraph companies send messages by radio, and by telephone and telegraph lines. Many people operate amateur radio stations. Such people are called *radio hams.*

Radio works by changing sounds or other signals into *electromagnetic waves,* also called *radio waves.* These waves travel through the air and through space. They also go through some solid objects, such as the walls of buildings. Radio waves travel at the speed of light—299,792 kilometres per second. A radio receiver changes them back into the original sounds.

Many people contributed to the development of radio and no one individual can be called radio's inventor. Guglielmo Marconi of Italy sent the first radio communication signals in 1895. Today, radio waves that are broadcast from thousands of stations, along with waves from other sources, fill the air around us continuously.

Uses

Broadcasting ranks as the most familiar use of radio by far. Every day, millions of people throughout the world listen to radio programmes that are broadcast for their entertainment and information. But people also use radio in dozens of other ways. Many uses involve *two-way communication,* in which radio equipment is used both to send and to receive messages. In broadcasting and most two-way communication, radio transmits sounds, such as voice and music. But in other kinds of uses, radio sends communication signals other than sounds. Such signals include the radio beams used in navigation and the remote control signals used in operating certain kinds of equipment.

Broadcasting

The scope of broadcasting. Radio broadcasts originate at radio stations. There is at least one radio station in every country in the world, and altogether there are more than 25,000 stations. About 11,000 of these stations are in the United States, which has more radio stations than any other country.

The people of the world own about 2 billion radios, or an average of about one for every three people. The United States has about 535 million radio sets, more than any other nation. India has about 68 million radios, which represents 8 radios for every 100 people. In the United Kingdom, which has about 66 million radios, there are 114 radios for every 100 people. On average, each United States household has six radios.

A major reason for the widespread use of radios is their *portability.* Portability means the ability to be carried around easily. Some radios are large and are powered by current from electric outlets. These radios are usually kept in the home, where electricity is readily available. But millions of radios are lightweight instruments that are powered by batteries. Some are small enough to fit inside a coat pocket. People listen to these radios almost everywhere—in homes and parks, at beaches and picnics, and even while strolling down the street. Radios are also widely used in cars. Nearly all modern cars have a radio. Therefore, millions of people can listen to radios while riding in cars.

Portable radios are merely a convenience in countries where electricity is readily available. But many homes in some parts of the world have no electricity. In such areas, portable radios provide the people with one of the few links they have to the world outside their own village or town.

Kinds of programmes. Radio programming varies from country to country. But in all countries, programmes primarily provide entertainment and information. In most countries up to 90 per cent of all programmes are designed for entertainment. The other 10 per cent provide some kind of information. Advertisements are broadcast during and between the programmes of *commercial* stations. Noncommercial radio services, such as the British Broadcasting Corporation's services, do not have commercials, although they do promote the products, services and programmes that they themselves provide.

Radio stations compete with one another for listeners. Most stations broadcast programmes to appeal to a specific audience. For example, stations that play pop music try to attract teenage and young adult listeners.

Entertainment. Recorded music is a popular kind of radio entertainment. Most music stations specialize in one kind of music, such as pop, popular, classical, jazz, or folk music. Some stations broadcast several kinds of music.

Radio stations that broadcast music have *disc jockeys* who introduce and comment on the music. They play an important role. A commercial music station tries to hire disc jockeys whose announcing styles and personalities appeal to the station's largest audience.

Not all radio entertainment is music. There are also comedy shows, serials, and plays performed "live" or recorded in the studio by actors. Some plays are written specially for radio.

Information. Programmes that provide information include news and current affairs, chat shows, and live broadcasts of sports events.

News bulletins are broadcast at regular times—every half-hour or hour on some stations. In addition, radio stations present on-the-spot news coverage of such special events as elections, or the opening of parliament. Radio stations also broadcast such specialized news as weather forecasts, traffic reports, and stock market and agricultural information. Other news features include announcements about community events, activities of community groups, and government services. A few stations broadcast only news to serve listeners who prefer news programmes to music. In some countries parliamentary proceedings are broadcast live.

Chat shows present discussions on a variety of topics and interviews with people from many professions. Each show has a host or hostess who leads the discussion or does the interviewing. The subject of a programme may be a current political topic, such as an election or a government policy, or it may deal with a social issue, such as crime, pollution, poverty, racism, or sexism. Many talk shows allow listeners to take part in the programme. Listeners are invited to telephone the station to ask questions or give their opinions about the topic. Such programmes are sometimes called *phone-ins.*

Sports events, like news, have always been an important part of radio programming. Sports announcers try to capture a game's action and excitement for the listeners. An account of a sports event given live by a radio broadcaster is called a *commentary.* Football, cricket, and tennis are among the popular sports broadcast on radio. Radio stations also broadcast sports results.

Two-way communication

Two-way communication is a widespread use of radio. Two-way radio provides communication in an almost endless variety of jobs—whenever there is a need for quick contact between one point and another. Some of the most important of these uses are in (1) public safety, (2) industry, (3) national defence, and (4) private communication.

In public safety. Police officers use radio to help prevent crimes and arrest lawbreakers. Radio also aids fire fighters in controlling and putting out fires. Police officers and fire fighters use two-way radios in their patrol cars and fire engines. They also carry small, portable two-way radios called *walkie-talkies.* They use these radios to get directions from their headquarters and to communicate with one another (see **Walkie-talkie**).

Aeroplanes and ships use two-way radios for safe operation, and for rescue missions.

Special ambulance teams use radio to help save lives after rushing to the scene of an accident. These specialists radio the details of a victim's condition to a doctor in a hospital. The doctor then directs the emergency treatment of the victim by radio.

In industry. Two-way radio has become a standard tool of the transportation industry, from taxicabs to jet airliners. Taxi drivers receive radioed instructions on where to pick up customers. Aeroplane pilots get landing and take-off directions by radio. Ships, trains, some buses, and many trucks are equipped with two-way radios.

Radio also helps save time, money, and work in many other industries. Construction workers use it to communicate from street level to the top of a skyscraper. With the aid of two-way radio, farmers, ranchers, and forestryworkers receive information when they need it and get equipment delivered where they want it.

In national defence, radio plays a key role by linking defence units in different regions. All branches of the armed services depend heavily on two-way radio communication. Military personnel use radio equipment in planes and tanks and on ships. Large communications centres and handy walkie-talkies help provide instant contact between military units.

In private communications. Many licensed radio operators send and receive long-distance messages by radio (see **Radio, Amateur**). Children play with walkie-talkies that broadcast short distances. Many people use two-way radios in such places as cars and pleasure boats. Radio used by private citizens for short-distance communication is called *citizens band radio* (see **Citizens band radio**). The development of *cellular radio* in the 1980's made it possible for people to use portable telephones almost anywhere and telephones installed in their cars.

Other uses

Radio waves can carry many more kinds of information than just sounds. Many important radio jobs involve the sending and receiving of various kinds of signals. Such signals make possible the operation of navigational aids, remote control devices, and *data* (information) transmission equipment. In addition, radio has several highly specialized uses.

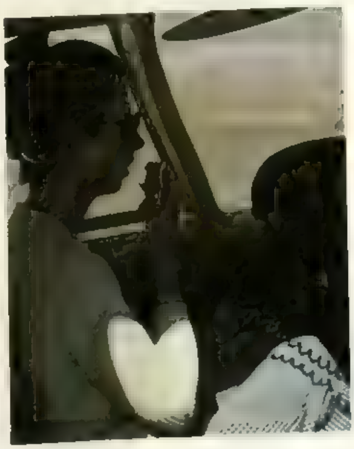
Navigation. Radio beams made up of special navigation signals help aeroplane pilots stay on the proper flying course (see **Aeroplane** [Flight navigation]). Many ships have devices for mapping their position with the aid of navigation signals that are radioed from shore (see **Ship** [A ship at sea]). Aeroplanes and ships also rely on radar—a special form of radio—for their safe operation (see **Radar**). In addition, radio-assisted navigational devices help astronauts guide their spacecraft exactly to their destination.

Remote control by radio can be used to guide the flight of a model aeroplane or a real plane that has no pilot. Radio-controlled devices also direct railway carriages in shunting yards. In addition, radio-controlled devices do such jobs as opening garage doors or operating machines (see **Remote control**).

Data transmission. Radio equipment can send information in much larger quantities and at much greater speeds than any person can. Data transmission usually occurs between one electronic device and another. An example of data transmission is the sending of information from radio equipment on the ground to a computer in a spacecraft. Radio is also used to send *facsimile images*. Images are converted into electronic signals, which are then transmitted by radio (see **Facsimile**).

Special uses. Spies use hidden radio devices called *bugs* to listen in on conversations in attempts to learn secret information. Doctors sometimes use radio to help them diagnose stomach illnesses. The patient swallows a *radio pill*—also called a *capsule radio*—that consists of a miniature radio transmitter enclosed in a capsule. While inside the stomach, the radio pill transmits signals that provide the doctor with medical information about the patient. Certain kinds of radio waves have so much energy that people can use them to cook their food. Radio waves cook food in microwave ovens (see **Microwave oven**).

A policeman's walkie-talkie keeps him in contact with other officers and with his headquarters.



A pilot radios the control tower for take-off instructions and for information about weather along the flight route.

A ship's radio operator types messages received from other vessels and from communications stations on land.

How radio works

The sending and receiving of all kinds of radio communications involve the same general steps. These steps include (1) creating the communication signals and changing them into radio waves, (2) *transmitting* (sending) the radio waves, and (3) receiving the radio waves and changing them into a form that can be understood. The following two sections—*How radio programmes are broadcast* and *How radio programmes are received*—describe the steps in radio broadcasting.

How radio programmes are broadcast

Radio stations are places where radio broadcasts begin. Many stations are located in office buildings. The heart of a radio station is the *studio.*

The studio is the room from which programmes are broadcast. It is soundproofed so that no outside sounds can get in and interfere with the broadcasts. Many studios have two separate sections—the *main studio area* and the *control room.* The main studio area is the place where the performers do their jobs. The control room is a booth containing much of the equipment needed to broadcast programmes. It is separated from the studio area by a wall. A large window in the wall allows the people in the studio area and control room to see one another. The control room includes a *control board,* a collection of instruments that regulate the sounds of broadcasts. Some programme activities, such as playing recorded music, usually take place in the control room, but may sometimes occur in the main studio area.

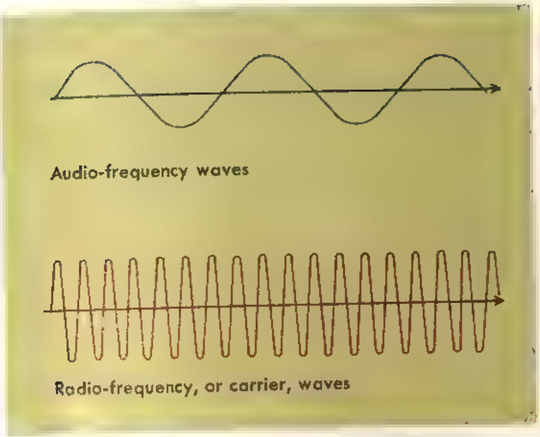
Putting a programme on the air involves such jobs as script writing, announcing, and controlling the broadcasting equipment. At a small station, the same person may write scripts, announce, play recordings, and even operate the controls. A large station has a staff that plans programmes, including the writing of news and other scripts. Once the programme goes on the air, the announcer reads a script or simply *ad-libs* (speaks without a script).

With the growing use of computers, more and more radio stations are becoming automated. Computers can do much of the work formerly done by people, such as operating technical equipment, recording programme information, sending out bills for the advertising department, and even running the control board. Automation saves money by reducing the number of employees at a station, or it allows a station's personnel to concentrate on more creative tasks.

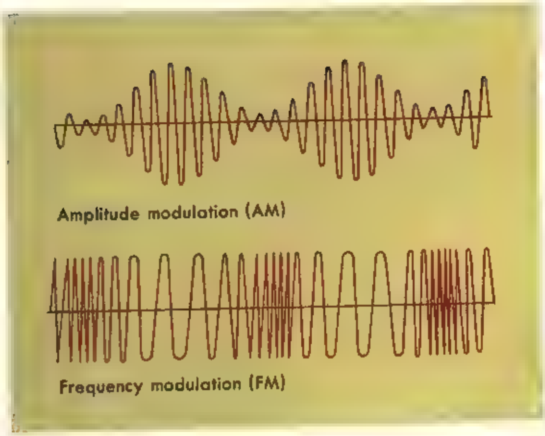
The production of a radio programme such as a play or a drama series is more complicated than for a music programme. Writers write scripts for comedies, dramas, and serials. A director guides the actors and actresses, who stand around a microphone and read their lines. An announcer may introduce the show, and close it. Sound-effects specialists create such sounds as thunder, footsteps, creaking doors, and galloping horses. An orchestra may play live music. Some radio shows are performed on a stage in a theatrelike studio before a live audience. Much modern programming, with its empha-

Radio terms

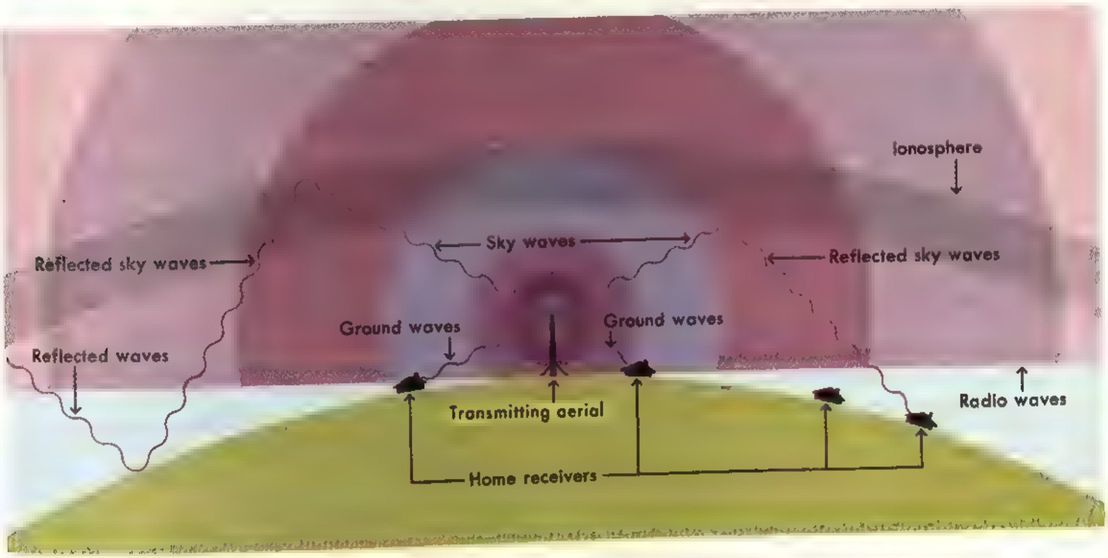
Ad-lib means to speak without a script.
AM stands for *amplitude modulation,* a broadcasting method in which the strength of the carrier waves is changed to match changes in the audio-frequency waves.
Audio-frequency waves are electric waves that represent the sounds of a radio broadcast.
Automatic frequency control (AFC) in an FM receiver is the circuit that automatically locks the tuner to the frequency of the selected transmitter.
Automatic volume control (AVC) is the circuit in a receiver that reduces unwanted changes in the audio signal, for example if the received radio signal varies in intensity because of atmospheric conditions.
Band spread is a special tuning knob on a short-wave receiver that allows tuning over a narrow frequency range, making it easier to select stations.
Bandwidth is the frequency range occupied by a transmitter. In the medium-wave band, each transmitter occupies a bandwidth of between 8,000 and 10,000 hertz.
Broadcast band is a range of radio frequencies allocated for use by broadcasting organizations. Some bands are for AM radio broadcasting, one is for FM radio broadcasting, and others are for television broadcasting.
Call letters are the initials that identify some radio stations.
Carrier waves "carry" the sounds of a programme by being combined with audio-frequency waves.
Channel is the radio frequency assigned to a station.
Detector is the electronic circuit that recovers the audio signal from a high-frequency radio signal.
FM stands for *frequency modulation,* a broadcasting method in which the frequency of the carrier waves is altered by changes in the audio-frequency waves.
Frequency is the number of times an electric wave vibrates each second.
Ground waves consist of the radio waves that spread along the ground away from a broadcasting aerial.
Ham is a name for the operator of an amateur radio station.
Hertz is a unit used to measure frequency. One hertz equals one vibration per second.
Kilohertz means 1,000 hertz.
Line-of-sight refers to the direct line in which FM waves travel, without "bending" over mountains or the curve of the earth.
Live broadcast consists of sounds made at the moment of the broadcast, without having been prerecorded.
Long-wave band is the frequency band ranging from 150 to 285 kilohertz used by several broadcasting stations in Europe and North Africa.
Medium-wave band is the frequency band ranging from 525 to 1,605 kilohertz, used by broadcasting stations throughout the world.
Megahertz means 1 million hertz.
Multiplexing means sending two or more separate signals on a shared channel, as in stereophonic radio transmissions.
Network is a group of stations that share the same programmes and usually transmit them at the same time.
Prerecorded means recorded on magnetic tape for broadcast at a later time.
Script is a written copy of the words to be spoken during a radio programme. It also specifies sound effects, music, and any other sounds to be made during a programme.
Selectivity is the capability of a receiver to separate two stations close together on the tuning dial.
Short-wave band is the frequency band ranging from 1.5 to 30 megahertz, used by broadcasting stations and a great number of services.
Sky waves consist of the radio waves that come from a transmitting aerial and go into the sky.
Stereophonic sound comes from at least two speakers to match as closely as possible the sounds people would hear with their two ears.
Transistor is a small electronic device that can amplify, modify or generate radio signals.



Radio waves are a combination of two kinds of electric vibrations, *above.* Audio-frequency waves represent voice and other sounds. Radio-frequency waves "carry" audio waves after being combined with them in one of the ways shown on the right.



AM and FM waves. In AM, the height of the combined audio- and radio-frequency waves varies to match the shape of the audio waves. In FM, the frequency of the combined waves is changed by the audio waves.



How broadcast waves travel. An aerial radiates waves in all directions. *Ground waves* reach nearby receivers but cannot go far beyond the horizon. *Sky waves* reflect from the ionosphere and reach distant receivers. They may also reflect from the earth and repeat the process.

sis on music and conversation, does not call for such a variety of production methods.

From sound waves to electric waves. A radio programme consists of speech, music, and other sounds. These sounds are either live or prerecorded. *Live* sounds are broadcast at the same time they are produced. They include the words spoken by announcers. They also include sounds that come from a *remote location,* such as commentaries on football matches and race meetings, or interviews and news reports brought in to the studio by telephone or from distant studios. *Prerecorded* sounds are not broadcast when first produced. They are stored on magnetic tape and broadcast later. Almost all the music and most commercials heard on radio are prerecorded.

To understand how radio broadcasting works, it is necessary to know what sound is. All sounds consist of vibrations. For example, the sound of a person's voice consists of vibrations of the air that are caused by the person's vibrating vocal cords. Sound travels through the air in the form of waves called *sound waves.* When the waves reach a person's ear, the person hears the original sounds.

During a radio broadcast, a microphone picks up speech and other live sounds that make up the programme. The microphone transforms sound waves into electric vibrations that represent the sound waves. These electric vibrations are amplified and used in the transmitter to produce the radio waves that make up the broadcast. In a similar way, the transmitting equipment

changes the prerecorded sounds of a programme into radio waves.

From electric waves to radio waves. The electric waves representing the sounds of a programme travel over wires to the control board. The control board has many switches and dials. A technician controls the sounds being sent to the board. The technician varies the *volume* (loudness) of each sound and may blend sounds together. From the control board, the electric waves go to the transmitter.

Transmitting radio waves. In some stations, the transmitter is in the same room as the control board, and the electric waves that make up the programme travel between the two instruments over wires. Other stations have their transmitter far from the radio station, at the site of the *transmitting aerial* (the device that sends radio waves through the air). In such cases, the electric waves are passed to the transmitters either by wire or by a special beam of radio waves.

The transmitter strengthens the incoming electric waves representing the broadcast. The transmitter also produces the radio waves called *carrier waves.* It combines the carrier waves with the electric waves from the radio studio—this process is called *modulation.* This combination of waves becomes the radio signal that brings the programme to radios.

The transmitter sends the radio signal to the aerial. The aerial, in turn, sends the signal out into the air as radio waves. Many stations locate their aerials on towers and in high or open areas, above and away from tall buildings and other structures that might obstruct the radio waves. Some stations, especially small ones, have their aerial on top of the station building or a nearby building.

Kinds of broadcast waves. A radio programme is transmitted in one of two ways, depending on the way the carrier wave and programme signal are combined. These two kinds of radio transmission are *amplitude modulation* (AM) and *frequency modulation* (FM). In AM transmission, the *amplitude* (strength) of the carrier waves varies to match changes in the electric waves coming from the radio studio. AM broadcasts usually use the long-wave, medium-wave, or short-wave band. In FM transmission, the amplitude of the carrier waves remains constant. But the *frequency* of the waves (the number of times they vibrate each second) is changed by the electric waves sent from the studio. FM broadcasts use radio waves of much shorter wavelengths than AM broadcasts.

An aerial sends out two kinds of radio waves—*ground waves* and *sky waves.* Ground waves spread out horizontally from the transmitting aerial. They travel through the air along the earth's surface and follow the curve of the earth for a short distance. Sky waves spread up into the sky. When they reach a layer of the atmosphere called the *ionosphere,* or the *Kennelly-Heaviside layer,* they may be reflected back down to earth (see **Ionosphere**). This reflection enables AM broadcasts to be received by radios that are great distances from the aerial. The ionosphere reflects radio waves from the medium-wave band much better at night. Therefore we can receive distant medium-wave broadcasting stations much more clearly during the nighttime than we can during the day.

An FM radio aerial sends out waves that can travel in the same directions as AM waves, but FM waves that go skyward are not reflected: they pass through the atmosphere and go into space. The FM waves that spread horizontally travel in what is called *line-of-sight.* This means that FM waves cannot be received farther than the horizon as seen from the aerial. AM broadcasts can be received at much greater distances than FM broadcasts because AM signals bounce off the ionosphere and reach beyond the curve of the earth.

Although their range is limited, FM broadcasts have an important advantage over AM broadcasts. FM programmes are not affected by static as much as AM programmes are. Most static signals are AM signals, and FM receiving circuits are designed to be insensitive to them. FM transmission also produces a much truer reproduction of sound than does AM. Many AM transmitters use the medium wave band, which is a relatively narrow frequency band, ranging from 525 kilohertz to 1,605 kilohertz. Because of the large number of broadcasting stations, each transmitter can only occupy a very narrow band, typically about 8,000 to 10,000 hertz wide. Since a high-fidelity audio signal needs a bandwidth of at least 20,000 kilohertz, AM transmitters do not broadcast high-fidelity audio signals. The audio signal of a typical AM transmitter does not carry sound with frequencies above 8,000 hertz, which results in a somewhat muffled sound.

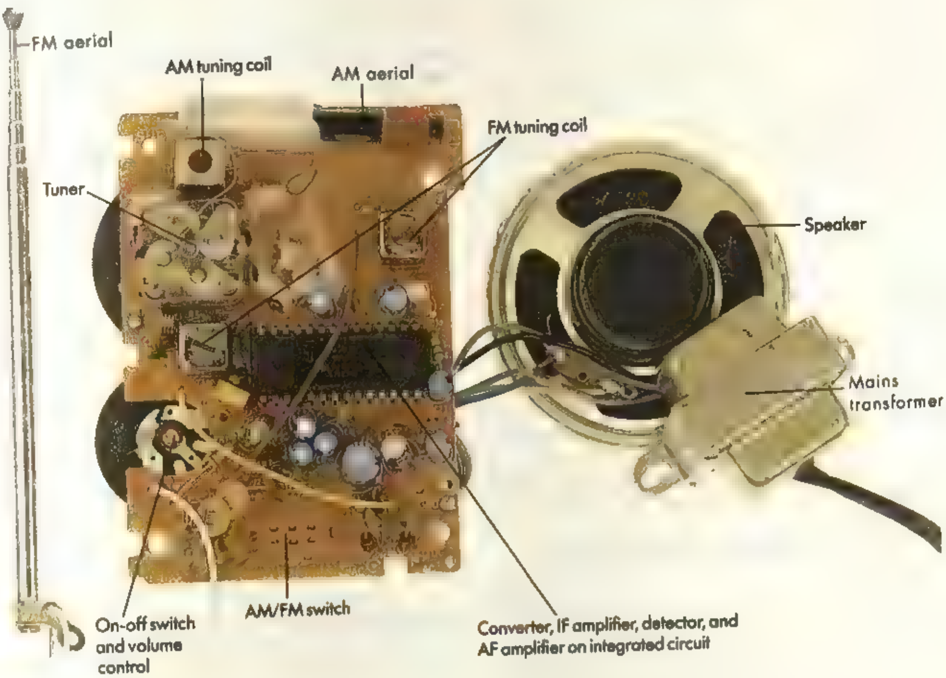
FM transmitters make use of a much wider frequency band, ranging from 88 megahertz to 108 megahertz. In some countries, FM stations broadcast on frequencies ranging from 65.8 to 73 megahertz. Each FM transmitter can occupy a frequency band that is wide enough for transmitting the full spectrum of sound, that is, audio frequencies up to 20,000 hertz. This results in a much crisper sound for the highest notes.

Broadcasting power and frequency. Another factor that influences the distance a radio programme can be broadcast is the power of the transmitter. Strong AM stations typically have a power of 50,000 watts. They can be heard far away, especially at night when sky waves are especially effective. For example, a 50,000-watt station can be heard at night by listeners about 1,600 kilometres away. Some low-power AM stations operate at 250 watts and usually serve only one or two towns. The power of most FM stations ranges from 100 watts, which can broadcast about 25 kilometres, to 100,000 watts, which can broadcast over 100 kilometres. Some noncommercial FM stations operate at as little as 10 watts and reach a distance of only a few kilometres.

Each station broadcasts on a different *channel,* or *assigned frequency.* The use of different frequencies keeps stations from interfering with one another's broadcasts. Frequency is measured in units called *hertz* (vibrations per second). One kilohertz equals 1,000 hertz and one megahertz equals 1,000,000 hertz. AM stations broadcast on frequencies between 525 and 1,605 kilohertz (medium waves) and, in Europe, between 150 and 285 kilohertz (long waves). A large number of broadcasting stations transmit in the short-wave bands that range from 1.5 to 30 megahertz.

A programme carried by radio waves travels at the speed of light. This speed is 299,792 kilometres per second. By contrast, sound waves themselves move

Main parts of an AM/FM transistor radio



through the air at a speed of only about 300 metres per second. As a result of the great difference in speed between radio waves and sound waves, a surprising effect occurs. A live radio broadcast of a concert taking place on the east coast of the United States would be heard by radio listeners on the west coast a fraction of a second before the music reached the audience in the back of the concert hall.

How radio programmes are received

Radio waves cannot be seen, heard, or felt in any way. But radio receivers pick them up and turn them into sounds that make up radio programmes.

Some radios are equipped to receive only AM broadcasts, and some only FM. Other radios are equipped to pick up both AM and FM broadcasts. A listener can flip a switch to select the AM medium wave *band* (group of frequencies) or the FM band. Receivers called *multiband radios* can pick up other bands too. Such bands carry short-wave broadcasts and aircraft and marine radio communication.

Almost all radio receivers operate on electric power from a wall outlet or battery. However, some simple radios, such as crystal radios—popular in the early days of radio broadcasting, work just on the power of the radio waves they pick up. A tiny germanium crystal in the receiver circuit detects the radio signals.

The main parts of an electrically powered radio include: (1) the aerial, (2) the tuner, (3) amplifiers, and (4) the speaker.

The aerial is a length of wire or a metal rod that picks up radio waves. It may be entirely inside the radio, or part of it may be outside the radio and connected to it, as is the case in car radios. The aerial in most portable medium- and long-wave receivers consists of a coil wound around a rod of a special magnetic material called *ferrite.*

When radio waves strike the aerial, they produce extremely weak electric currents in the aerial. However, an aerial receives radio waves from many stations at the same time. To hear a single programme, a listener must tune the radio to the desired station.

The tuner is the part of a radio that makes it sensitive to particular frequencies. A dial attached to the tuner shows the frequencies, or channels, of the stations that may be tuned in. For example, in the United Kingdom, the British Broadcasting Corporation's World Service is broadcast on a frequency of 648 kilohertz. To tune in to the World Service, a listener sets a radio tuner to the number 648.

The heart of a tuner is a component called a *variable capacitor.* This device consists of two sets of semicircular metal plates. The two sets mesh closely together. One set never moves. The other set shifts its position when a person twists the tuning control. This shifting produces changes in the radio's circuits that make the radio sensitive to various frequencies.

Amplifiers strengthen the programme signal selected by the tuner. The amplifiers in a typical radio are parts of what is called a *superheterodyne* circuit. In most radios sold today, the main operating parts of this circuit are transistors and integrated circuits. Most radios made before 1960 used valves, also called vacuum tubes.

The superheterodyne circuit has four main sections: (1) converter, (2) intermediate-frequency (IF) amplifier, (3) detector, and (4) audio-frequency (AF) amplifier. First, the converter changes the weak incoming radio signal to a lower frequency called the intermediate frequency. The signal then goes to one or more IF amplifiers, which strengthen it. The signal next enters the detector. The detector removes the carrier wave from the signal and leaves only the *audio frequency*—the part that represents the programme. Finally, one or more AF amplifiers strengthen the audio-frequency part of the signal and send it to the speaker.

The speaker is the final link between the broadcasting studio and the listener. It changes the electric signal back into the original programme sounds. The basic parts of a speaker are a permanent magnet and a coil of wire called the *voice coil.* The voice coil is attached to a cone, which is usually made of paper. The audio signal from the final amplifier passes through the coil and magnetizes it, causing it to move in the permanent magnet's field. The cone vibrates in time with the audio signal flowing through the coil. The cone's vibrations create sound waves like those that first went into the microphone, thus reproducing the original sounds.

Stereophonic receivers pick up *stereophonic,* or *stereo,* programmes. At least two microphones are needed to produce such a programme. Usually, three or more microphones are used. The microphones capture sounds as they might be heard in a theatre or concert hall. The microphones, like a person's two ears, "hear" differences in sounds that are coming from various locations on a stage. A technique called *multiplexing* is used to transmit stereo sounds on a single transmitter.

Stereo receivers have at least two speakers, one each for sounds coming from the right and left. Sometimes, both speakers are inside the receiver. But for improved stereo reception, the speakers are outside the radio at certain distances from it. The listener locates the speakers in such a way that they duplicate the original sounds as closely as possible.

Short-wave radio

A large number of broadcasting stations operate in the short-wave bands. In broadcasting, short waves are defined as those with frequencies between 1.5 and 30 megahertz. Broadcasting stations occupy a number of frequency ranges that are named after their wavelength. For example, the frequency band from 17.7 to 17.9 megahertz is called the 16-metre band. Other bands used by short-wave broadcasting are the 11-, 13-, 19-, 25-, 31-, 41-, and 49-metre bands.

In the tropics, broadcasting stations use in addition the 60-, 75-, 90-, and 120-metre bands. The other frequencies are used by radio amateurs, military communications systems, marine and aeronautical communications and navigation, and teletype services. Because of reflection by the *ionosphere* (the layer in the atmosphere that reflects radio waves), short-wave broadcasts travel over long distances, and in some sparsely populated areas of the world they are the only broadcasts that can be received.

Short-wave broadcasting. More than 80 countries operate short-wave broadcasting stations. Generally, programmes transmitted by these stations differ from the local programmes because they are addressed to audiences far away. Programmes in the national language are made for nationals living in other countries or working on ships.

Programmes in other languages are directed toward specific countries. For example, the BBC World Service broadcasts not only in English, but also in other languages, such as Russian, Arabic, French and German. In the United States, The Voice of America transmits programmes in several languages; so do Radio Moscow and Radio Beijing.

Most short-wave broadcasting stations transmit on several frequencies, and in several frequency bands simultaneously, to ensure worldwide reception. For example, a listener in Europe tuning in to an American short-wave station, will receive the station clearly in the 19-metre band in the morning, and in the 31-metre band at night.

Programmes broadcast by short-wave stations consist mainly of international and national news, commentaries, interviews, cultural programmes, reviews of sports events, and radio plays. Some stations, such as

Frequency bands

	Wavelength metres			Frequency kilohertz		
Long wave	2000	to	1060	150	to	280
Medium wave	571	to	187	525	to	1605
Short wave, Tropical bands						
120-metre band	130.0	to	120.0	2300	to	2498
90-metre band	93.7	to	88.2	3200	to	3400
75-metre band	76.9	to	75.0	3900	to	4000
60-metre band	63.2	to	59.3	4750	to	5060
Short wave bands						
49-metre band	50.3	to	48.4	5950	to	6200
41-metre band	42.3	to	41.1	7100	to	7300
31-metre band	31.6	to	30.7	9500	to	9775
25-metre band	25.6	to	25.1	11700	to	11975
19-metre band	19.9	to	19.4	15100	to	15450
16-metre band	16.9	to	16.6	17700	to	17900
13-metre band	14.0	to	13.8	21450	to	21750
11-metre band	11.7	to	11.5	25600	to	26100

the BBC World Service, transmit English language courses. Because of atmospheric conditions and interference, the sound quality of short-wave reception is generally poor, therefore music programmes are transmitted less frequently.

During the *Cold War* (the period of antagonism between Communist and non-Communist countries that lasted from the 1940's to the 1980's), short-wave broadcasting stations were often used for political propaganda purposes. Some governments in Eastern Europe, especially those that tightly controlled local broadcasts, jammed broadcasts from the West.

Short-wave receivers. Many broadcasting receivers feature one or several short-wave bands as well as the AM medium-wave band and the FM band. Because short-wave bands are very crowded, tuning can be difficult. Short-wave broadcasting frequencies are very close to each other—they have a separation of only 5 kilohertz between them. In many cases, a normal radio receiver cannot separate them and two stations may be audible at the same time. Far better reception is possible with special short-wave receivers, sometimes called *communications receivers.* Such receivers have a much higher sensitivity, allowing reception of very weak signals. Their selectivity is also much higher, making it possible to separate two transmitters that are very close on the dial.

In some advanced receivers the selectivity, or bandwidth, is adjustable. Increasing the bandwidth improves the sound quality of the broadcast, but makes it more difficult to separate it from other, closer, stations. An important feature of a short-wave receiver is the *bandspread* (a special tuning knob that allows tuning over a narrow frequency range), which makes it easier to find a specific broadcasting station. Other features of short-wave receivers are a signal intensity meter or tuning indicator and a circuit that eliminates or reduces noise caused by interference.

The manufacture of radios provides job opportunities for a variety of skilled workers, from technicians to electronics engineers. The technician shown above is assembling radio parts.

Short-wave receivers generally use a wire or telescopic rod aerial. The small ferrite aerials that are mounted inside medium- and long-wave receivers are not suitable for short-wave reception.

More recently, short-wave receivers with digital tuning have appeared on the market. Such receivers are equipped with a numerical keypad, similar to the keypad on a push-button telephone. The listener selects the station by keying in its frequency. The selected frequency is displayed on a small liquid-crystal screen. In some receivers it is possible to store several frequencies in memory, and retrieve them by pressing a single digit. For example, you can store the frequencies in different frequency bands of the same station and quickly select the waveband that gives best reception.

Short-wave reception depends on several factors that influence the ionosphere. Radio waves of longer wavelength are more easily reflected at night, while shorter waves of 10 to 20 metres travel farther during the day. This explains why the reception of distant stations depends very much on the time of day. Solar activity also plays a role in long-distance reception. Around the time of a *solar maximum* (the time when solar activity is greatest) the ionosphere reflects short waves better, and the number of distant broadcasting stations that one can receive becomes much larger. However, magnetic storms, caused by solar flares, disturb the ionosphere and sometimes cause total blackouts of short-wave reception.

Leading countries in number of radios

Country	Number of radios	Radios per 100 people
United States	534,800,000	212
China	213,000,000	18
Japan	112,500,000	91
Germany	70,000,000	88
India	68,500,000	8
United Kingdom	65,800,000	114
Brazil	58,500,000	40
France	50,600,000	89
Russia	49,046,000	33
Italy	45,650,000	79
South Korea	43,850,000	100
Ukraine	41,300,000	118
Canada	27,776,000	105
Indonesia	27,500,000	15
Argentina	22,300,000	68
Australia	22,000,000	127
Mexico	22,000,000	26
Nigeria	19,350,000	17
Egypt	17,500,000	33
Poland	16,600,000	43
Iran	13,860,000	23
Czechoslovakia	13,692,000	87
Netherlands	13,650,000	91
South Africa	11,800,000	30
Pakistan	10,980,000	9

Figures are for 1991, prior to the breakup of Czechoslovakia.
Source: UNESCO

Radio has several important industrial roles. Broadcasting stations provide jobs for thousands of workers around the world. Stations and networks need programme planners and announcers, news reporters and newscasters, technicians, and maintenance workers. Other personnel write scripts, sell advertising time, and work in such general business activities as accounting and public relations. Employees of large stations or networks generally specialize in one of four kinds of work. These are (1) programming, (2) engineering, (3) sales, or (4) general administration. Radio commercials help other businesses sell every kind of product—from dog food to cars. The recorded music played by disc jockeys is probably the most important factor affecting the sale of records and tapes. Shops throughout the world sell millions of radio receivers each year. Often people in one household own many radios.

Broadcasting services

Stations and networks. The organization of radio broadcasting varies from country to country. For example, the United States has more than 9,500 commercial radio stations. Almost all are privately owned businesses. In Australia, New Zealand, the United Kingdom, and most European countries, there are both commercial stations and nonprofit stations. Some countries, including India and Malaysia, have no commercial radio stations.

Australia has a three-tier system, with commercial stations, *national* stations funded by the federal government, and *public* stations owned by nonprofit corporations. There are over 130 commercial radio stations, and 32 public broadcasting stations. The Special Broadcasting Service (SBS) operates ethnic and multicultural stations which broadcast in about 45 languages.

The British Broadcasting Corporation (BBC) is the United Kingdom's major national radio broadcasting organization. Its stations do not carry advertisements. The BBC has five national services, as well as regional radio services such as Radio Cymru (in Welsh), and more than 30 local stations. Local stations can be linked to the national service by a *network* arrangement, so that national programmes can be broadcast on local stations. In the UK, there are also over 50 commercial stations, both national and local.

In most of Asia and Africa, radio listening is not so widespread as it is in Europe, America, and Australia. In India, many people do not have radios of their own. Instead, they listen to All India Radio programmes in tea shops and other public places. All India Radio broadcasts in 60 different languages and dialects. Radio in India is an important means of education. Farmers can obtain information about agricultural developments by listening to the radio.

Commercial radio stations broadcast programmes to attract listeners. The stations sell broadcasting time to advertisers who want to reach these listeners. Advertisers pay the stations for time during and between the programmes to advertise their products. Stations that attract the largest audiences receive the highest fees. Many commercial stations have an *affiliation* (working agreement) with a national *network*. A network is an organization that provides some of the programming, for example the news broadcasts, for its affiliated radio stations.

Broadcasting stations are increasingly assuming a more important role in local communities. They announce local forthcoming events and local problems are discussed in phone-in programmes. In metropolitan areas commuters listen to updates about traffic, route diversions and obstructions, and changes to transportation services.

Government regulation of radio. The government of every country regulates the use of radio in some way. One reason for regulation is the need to maintain order among users of radio channels. Without such regulation, radio stations and other radio users would broadcast signals that would interfere with one another and make it impossible for communications to be understood. Many governments also regulate radio for another reason. They want radio to be used to promote their own ideas and policies. They also want to be able to prevent the broadcast of ideas that they oppose.

The British Broadcasting Corporation is a nonprofit corporation. It is a public body financed by the licence fees paid by owners of television sets. The Independent Broadcasting Authority appoints companies to run commercial stations, supervises programme arrangements, and controls advertising. There is a complaints commission, which deals with allegations of unfair treatment or infringement of privacy. A broadcasting standards council monitors programmes and examines complaints from listeners about the portrayal of violence and sex.

Radio Telefís Éireann (RTE) is responsible for radio broadcasting in the Republic of Ireland. Revenue comes from licence fees and from payments made for commercials. The government appoints the nine members of the RTE authority, the chief of whom is the director general.

National radio in Australia is run by the Australian Broadcasting Corporation (ABC). The Australian Broadcasting Tribunal grants new broadcasting licences to public and commercial stations, and renews old ones. It also controls the stations' programming.

In New Zealand, the Broadcasting Corporation of New Zealand (BCNZ) is a public corporation. It controls both commercial and noncommercial networks.

In South Africa, the South African Broadcasting Corporation (SABC) broadcasts more than 20 radio services, six of which are nationwide. Board members are appointed by the state president, but day-to-day running of the corporation is in the hands of the director general and a management committee.

In many countries, the government controls radio broadcasting. In general, a country allows radio broadcasters the same degree of freedom it allows its citizens. Most democratic countries allow wide freedom in broadcasting. Many totalitarian governments severely regulate and censor broadcasting for political purposes.

Totalitarian governments have used radio as an instrument of policy. In Nazi Germany in the 1930's, the government used the radio for propaganda broadcasts. These broadcasts were used to increase the popularity of the Nazi leader, Adolf Hitler. Many Communist governments have used radio in the same way, to present a biased account of what is going on in the world. Broadcasters were not free to plan and present radio programmes. In Eastern Europe, radio broadcasters began to enjoy the same freedoms as their colleagues in the West after the democratic reforms of the late 1980's and early 1990's.

Guglielmo Marconi invented a way of sending telegraph signals by radio in 1895. His invention helped lead to the development of broadcasting. This photograph shows him with some of his wireless equipment.

A "crystal" radio of the early 1920's worked without batteries or other source of power, but a listener needed earphones to hear it.

A radio of the mid-1920's was powered by electricity and had a trumpetlike loudspeaker.

By the early 1940's, radios had become "streamlined." Members of a family often got together to listen to programmes.

The development of radio in the late 1800's revolutionized communication. At that time, people had two other means of quick, long-distance communication—telegraph and telephone. But the signals sent by both these devices had to travel through wires. As a result, telegraph and telephone communication was possible only between places that had been connected by wires. Radio signals, on the other hand, passed through the air. Therefore, radio enabled people to communicate quickly between any two points on land, at sea, and—later—in the sky, and even in space.

Radio broadcasting, which began on a large scale during the 1920's, caused major changes in the everyday lives of people. It brought a tremendous variety of entertainment into the home for the first time. It also enabled people to learn about news developments as they happened or shortly afterward.

Early development. Radio, like many other inventions, developed from the theories and experiments of many people. An American professor, Joseph Henry, and a British physicist, Michael Faraday, developed one of the first important theories in the early 1800's. Henry and Faraday had experimented with electromagnets. Working separately, they each developed the theory that a current in one wire can produce a current in another wire, even though the wires are not connected. This idea is called the *induction theory.* In 1864, James Clerk Maxwell, another British physicist, helped explain the induction theory by suggesting the existence of electromagnetic waves that travel at the speed of light. In the 1880's, the German physicist Heinrich Hertz performed experiments that proved Maxwell's theory to be correct (see **Hertz, Heinrich**).

In 1895, Guglielmo Marconi, an Italian inventor, combined earlier ideas and his own ideas and sent the first radio communication signals through the air. He used electromagnetic waves to send telegraph code signals a distance of more than 1.5 kilometres. In 1901, Marconi's radio equipment sent code signals across the Atlantic Ocean from England to Newfoundland.

During the early 1900's, electrical engineers developed various kinds of valves (vacuum tubes) that could be used to detect and to amplify radio signals (see **Vacuum tube**). Lee de Forest, an American inventor, pat-

ented a valve called a *triode,* or *audion,* in 1907. This valve could amplify radio signals and became the key element in radio reception.

There are many claims for the first broadcast of human speech over the air. Most historians give credit to Reginald A. Fessenden, a Canadian-born physicist. In 1906, Fessenden spoke by radio from Brant Rock, Massachusetts, U.S.A., to ships offshore in the Atlantic Ocean. The American inventor Edwin H. Armstrong did much to improve radio receivers. In 1918, he developed the superheterodyne circuit. These circuits, still used today, have a high selectivity. Later, in 1933, Armstrong developed FM broadcasting.

The first practical use of the "wireless," as radio telegraphy was called, was for ship-to-ship and ship-to-shore communication. Radio helped save the lives of thousands of victims of sea disasters. The first sea rescue involving the use of radio took place in 1909, after the S.S. *Republic* collided with another ship in the Atlantic Ocean. The *Republic* radioed a call for help that brought rescuers who saved almost all the passengers. Radio also aided in the rescue of the survivors of the famous *Titanic* shipwreck in 1912.

Dozens of new uses were soon found for radio. By the 1930's, aeroplane pilots, police, and military personnel were using radio for quick communication.

The start of broadcasting. Experimental radio broadcasts began about 1910. In that year, Lee De Forest produced a programme from the Metropolitan Opera House in New York City. The programme starred the famous singer Enrico Caruso.

Radio services in many countries began in the 1920's. One of the first commercial stations was station WWJ in Detroit, U.S.A., which began regular broadcasts on Aug. 20, 1920. Another U.S. radio station, KDKA of Pittsburgh, began as an experimental station in 1916 and in 1920 broadcast the U.S. presidential election results.

Australia's first radio station was 2SB, or Sydney Broadcasters (Limited), which began transmitting on Nov. 13, 1923. A commercial station, 2UE, began broadcasting in Australia on Jan. 26, 1925. In New Zealand, the government first authorized the Radio Broadcasting Company of New Zealand to operate radio stations in 1926. This company was replaced by the New Zealand Broadcasting Board in 1932.

Ireland's first radio service began in 1926. It was a part of the government's Department of Posts and Telegraphs until 1960. It then became a corporation which developed into *Radio Telefís Éireann.* The UK's BBC began as a company formed by makers of radios and electrical equipment. It first broadcast in 1922, and became a public corporation in 1927. On December 25, 1932, King George V made the first royal Christmas Day broadcast to many countries around the world that were then part of the British Empire. The king's voice was heard as far away as Australia and New Zealand.

In the 1920's, radio broadcasting began in South Asia. The first Indian radio company, the Indian Broadcasting Company, was given a licence in 1926 to set up radio stations and to broadcast. But because few people bought licences for radios, the company went out of business. The Indian State Radio Service was set up in 1932, and, in 1936, was renamed All India Radio. In 1947, all radio stations in Pakistan were handed over to the government of that country. Radio in Asia is commonly government controlled, and confined to urban areas.

The years before and after World War II (1939-1945) were for many broadcasters a "golden age" of radio. In this period, before television was widespread, radio programmes in America, Australia, and Europe enjoyed large audiences.

The golden age of radio lasted from the late 1920's to the early 1950's. During this period, radio was a major source of family entertainment. Every night, families throughout the country gathered in their living rooms to listen to comedies, action-packed adventure dramas,

A sound-effects expert used odd-looking equipment to create realistic sounds for a radio drama. This picture shows water being sprayed into a bucket to make the sound of rain.

The golden age of radio brought the voices of many famous people to listeners. Queen Elizabeth, wife of King George VI, broadcast to the United Kingdom in 1939.

music, and other kinds of radio entertainment. Children hurried home from school to hear special programmes designed for them. During the daytime, millions of women listened to dramas that were called *soap operas* in the U.S.A. because soap manufacturers sponsored many of them.

Radio comedy produced many famous comedians including George Burns and Gracie Allen, Jack Benny, and Bob Hope in the United States, and Arthur Askey and Tommy Handley in the United Kingdom. Wartime radio in the 1940's attracted huge audiences. People "tuned in" to listen to the speeches of Winston Churchill and other Allied leaders. Workers in factories making armaments listened to music while they worked, and also enjoyed radio variety shows.

Radio brought music of all kinds into the home, from classics to jazz. Famous bandleaders became stars of the radio. They included Tommy Dorsey, Duke Ellington, Glenn Miller, Henry Hall, and Billy Cotton. Exciting radio dramas included "Buck Rogers in the 25th Century", "Superman", "Paul Temple", "Dick Barton, Special Agent", and "Journey into Space". There were many popular radio serials, including "The Archers", which continued its popularity in the UK into the 1990's. There were also popular discussion programmes such as "The Brains Trust", and quiz shows.

George Burns and Gracie Allen were famous U.S. radio performers during radio's golden age. The husband-and-wife team starred in a popular weekly situation comedy from 1932 to 1950.

Important dates in radio

1864 James Clerk Maxwell predicted the existence of electromagnetic waves that travel at the speed of light.
1880's Heinrich Hertz proved Maxwell's theory.
1895 Guglielmo Marconi became the first person to send radio communication signals through the air.
1901 Ferdinant Braun received radio waves with a crystal detector.
1901 Guglielmo Marconi received coded signals transmitted across the Atlantic Ocean.
1904 John Ambrose Fleming patented the diode, a valve used for receiving radio waves.
1906 Reginald A. Fessenden broadcast voice by radio.
1907 Lee de Forest patented the triode, the first valve used for the amplification of radio signals.
1909 Passengers of the S.S. *Republic* were saved in the first sea rescue using radio.
1912 Radio aided the rescue of survivors of the sunken liner *Titanic.*
1915 The first transatlantic telephone call is made between Arlington, Virginia, U.S.A., and the Eiffel Tower in Paris.
1918 Edwin H. Armstrong developed the superheterodyne circuit.
1920 Stations WWJ of Detroit and KDKA of Pittsburgh made the first regular commercial broadcasts.
1922 The British Broadcasting Company, later the British Broadcasting Corporation, made its first radio broadcast.
1923 Sydney Broadcasters in Australia began transmitting radio programmes.
1926 The Indian Broadcasting Company started operation.
1929 Introduction of frequency modulation (FM) in radio broadcasting.
1932 The British Broadcasting Corporation made its first *Empire Service* (World Service) broadcast.
c. 1925-1950 Radio was a major source of family home entertainment, during the so-called "golden age" of radio.
1947 Scientists at the Bell Telephone Laboratories in the U.S.A. developed the transistor.
1952 Introduction of the first pocket-sized transistor radios.
1960 John F. Kennedy and Richard Nixon held the first radio and television debates between two U.S. presidential candidates.
1961 Soviet space officials held the first radio talks with a man in space, cosmonaut Yuri Gagarin.
1960's Stereophonic radio broadcasting began.
1969 Radio signals carried to earth the first words spoken by astronauts on the moon.

In the 1950's there were popular new comedy shows on radio, such as "The Goon Show." Ventriloquists Edgar Bergen, with his dummy Charlie McCarthy, and Peter Brough, with dummy Archie Andrews, had their own radio shows. Request programmes, to which listeners sent in requests for a particular musical record, with a message, were increasingly popular. Children's radio was a feature in the 1940's and 1950's, with the BBC's "Children's Hour" programme attracting praise for its mixture of education, excitement, and entertainment.

The impact of radio was demonstrated in a surprising way on Oct. 30, 1938. On that day in the United States, there was a radio programme called *The War of the Worlds.* The programme was one in a series of dramas put on by Orson Welles, the American actor-producer, and his Mercury Theater on the Air. The programme, adapted from the science-fiction novel of the same name by the British author H. G. Wells, took the form of on-the-spot news reports describing an invasion of New Jersey by aliens from Mars. The announcer told the radio audience that the show was fictional. Even so, large numbers of listeners believed the invasion was actually taking place, and widespread panic resulted. Thousands of people called the police and other authorities for instructions on what to do. Many people fled their homes, some taking furniture with them. Still others were treated in hospital for shock.

Some radio news reporters became almost as well known as the top entertainers. They included the Americans Walter Winchell and Edward R. Murrow, and Richard Dimbleby of the United Kingdom. Newscasts be-

came especially important during World War II (1939-1945). Millions of people turned to radio for the latest war news every day. The governments of countries that fought in the war made widespread use of broadcasts to their own and other countries for propaganda and other purposes. Political leaders, such as Winston Churchill and Charles de Gaulle, made use of radio to address their nations.

The BBC broadcast coded messages to occupied Europe during World War II. From Germany, listeners in the United Kingdom heard broadcasts of the traitor William Joyce, known as "Lord Haw-Haw", who was used by the Nazis to broadcast false information about the war.

Politicians soon realized the effectiveness of radio as a means of influencing voters. U.S. President F. D. Roosevelt, president from 1933 to 1945, was famous for informal radio broadcasts called *fireside chats*. Radio provided an opportunity for taking government policies directly to millions of people in the country. Since the 1940's, politicians have used radio broadcasts as a way of getting their message to millions of voters, although, with its increasing popularity from the 1950's, television has replaced radio in many countries as the most powerful mass-audience medium.

Broadcasting today. The rise of television in the 1950's ended the golden age of radio broadcasting. People turned to TV for comedies, dramas, and variety shows. Many people believed television would cause radio broadcasting to become an unimportant communication medium with a very small audience. Instead, radio's audience has continued to grow, in spite of competition from television.

There are several reasons for radio broadcasting's continued growth. Music has become the major form of radio entertainment. Rock music—which was a new form of music in the 1950's—became an important kind of music on radio. Broadcasts of pop music gained many listeners—especially teenagers—for radio. In addition to pop, there are many other kinds of music available on radio. Lovers of all kinds of music can turn to radio to hear their favourite recordings.

Other developments in programming have helped gain listeners for radio. These developments include chat shows, phone-ins, and stations that broadcast only news. An important feature of such programmes is their thorough coverage of a topic or news events. Some industrial nations now have stations that specialize in providing a service for a particular group of people or in transmitting only one kind of music. Local radio stations in some busy cities broadcast regular travel reports, warning commuters of any traffic problems and delays or cancellations in urban transportation systems.

Another reason why radio broadcasting has continued to grow is the increased popularity of portable radios. Portable radios have made radio a source of personal, rather than family, enjoyment. Car radios have also shown a dramatic growth. Today, nearly all the cars made in Europe, Japan, and the United States have radios.

The increasing popularity of FM broadcasts has also contributed to the growth of the radio industry. FM's better sound quality enabled it to surpass AM in popularity in the late 1970's.

Still another aid to radio's growth has been the development of stereophonic broadcasting. Stereo broadcasts began on a large scale in the 1960's. The 1970's and 1980's saw soaring sales of stereo radio receivers, including portable sets. These receivers are favourites of people who want to listen to music that sounds almost the same as live performances. Music concerts and radio dramas are among the programmes that are broadcast in stereo.

Related articles in *World Book* include:

Biographies

De Forest, Lee
Hertz, Heinrich R.
Lodge, Sir Oliver J.
Marconi, Guglielmo
Maxwell, James Clerk

Parts of a radio

Aerial
Headphones
Microphone
Speaker
Transistor

Radio equipment

Citizens band radio
Facsimile
Radar
Radio telescope
Radiosonde
Remote control
Satellite, Artificial
Television
Walkie-talkie

Other related articles

Advertising
Aeroplane (Flight navigation)
Australian Broadcasting Commission
Automatic frequency control
British Broadcasting Corporation
Communication
Electronics (Amplification; Rectifying signals)
Frequency band
Frequency modulation
High fidelity system
Invention
Ionosphere
Journalism (Radio; Radio journalism)
Kilohertz
Public opinion (Radio and television)
Radio, Amateur
Radio Free Europe/ Radio Liberty
Reflection
Ship (A ship at sea)
Short waves
Static
Telephone (Long distance lines)
Ultrahigh frequency waves

Outline

I. Uses
- A. Broadcasting
- B. Two-way communication
- C. Other uses

II. How radio works
- A. How radio programmes are broadcast
- B. How radio programmes are received

III. Short-wave radio
- A. Short-wave broadcasting
- B. Short-wave receivers

IV. Broadcasting services
- A. Stations and networks
- B. Government regulation of radio

V. History

Questions

What are the basic steps in all kinds of radio communication?
What were the contributions of James Clerk Maxwell, Heinrich Hertz, and Guglielmo Marconi to the development of radio?
What is a radio network?
In what ways did radio programming change after the rise of television?
Why does a radio need an aerial?
What are some important applications of radio?
How is broadcasting regulated by governments?
What was the golden age of radio? Why did it end?
In what ways is the radio industry important to the economy?
How do AM and FM broadcasting differ?

An amateur radio station may use a transceiver, *above.* The operator sends messages by speaking into a microphone and listens to other hams through headphones or a speaker.

Some hams build satellites that link radio amateurs worldwide. Several such satellites, called *Oscars* for *O*rbiting *S*atellite *C*arrying *A*mateur *R*adio, have been launched into orbit.

Radio, Amateur, is a popular hobby in which an individual operates his or her own radio station. Amateur radio is often called *ham radio,* and the operators are frequently referred to as *hams.* Hams can send radio messages by voice or by international Morse code to other radio amateurs throughout the world. Nearly a million people participate in amateur radio. Boys and girls younger than 7 years old have operated their own amateur radio stations. One can easily pick up conversations between radio amateurs on the short wave band of a radio receiver, especially on the 15-metre, 40-metre, and 80-metre bands. Listening to them requires careful tuning because the power of ham transmitters is much lower than those of broadcasting stations.

Amateur radio differs from a type of radio operation called *citizens band,* or *CB, radio.* Citizens band carries fewer channels than amateur radio, and is more limited in the power and range of its signal. For more information on CB, see **Citizens band radio.**

Many hams especially enjoy talking with other radio amateurs who live in faraway places. When contacting hams in other countries, amateurs have little difficulty with language barriers. Many hams around the world speak English. When communicating by means of international Morse code, amateurs may use an internationally accepted set of three-letter signals. These signals are called *Q signals* because they all begin with the letter Q. For example, the signal *QTH?* means "What is your location?" Q signals enable amateur-radio operators who do not speak a common language to understand each other.

Amateur frequency bands

(Short-wave and UHF bands)

Frequency (kilohertz)	Band
1,810 - 2,000	160-metre band
3,500 - 3,800	80-metre band
7,000 - 7,100	40-metre band
14,000 - 14,350	20-metre band
21,000 - 21,450	15-metre band
28,000 - 29,700	10-metre band
70,000 - 70,500	4-metre band
144,000 - 146,000	2-metre band

Uses of amateur radio. Hams have a long history of providing communication assistance in times of emergency. Floods, fires, tornadoes, and hurricanes can interrupt telephone service and other common means of communication. Radio amateurs often have used their equipment during such disasters to reestablish vital communication links. This kind of voluntary work in emergencies has won hams the praise of governments around the world.

Some radio amateurs have developed equipment for sending television pictures over radio waves. Others send messages all over the world by bouncing their signals off the moon. Hams have even used their radio equipment to transmit information from one computer to another.

One technically challenging activity involves building and using an amateur radio communications satellite. Many nations have allowed these satellites to "hitchhike" into orbit as part of the launch of other satellites. Most of these communications satellites have been called *Oscars.* The word *Oscar* comes from *O*rbiting *S*atellite *C*arrying *A*mateur *R*adio. Many schools tune in Oscars to provide students with firsthand experience in space science.

Equipment. Some amateurs design and build their own stations. Other assemble receivers and transmitters from do-it-yourself kits. This way they are able to assemble a complete station at a reasonable cost. Many amateurs feel that building and designing equipment is an important part of their hobby. Some radio amateurs operate transmitters and receivers that are converted military sets or use their components to assemble them. Others use highly sophisticated equipment that performs as well as the most expensive commercial radiocommunication systems. A complete amateur radio station includes an aerial, a transmitter, and a receiver. Many amateurs use a transceiver, which combines a transmitter and a receiver in a single unit. Many ama-

teurs operate mobile equipment. Receivers and transmitters are mounted in a car, and the aerial either is mounted on the car or can be set up outside the car once it has been parked at a suitable site. Some amateurs now use computers to transmit and receive messages in binary code.

Licences. Unlike most other hobbies, amateur radio requires a licence in most countries. Amateurs share short-wave radio *frequencies* (channels) with such users as airlines, armed forces, police, ships, and television broadcasters (see **Short waves**). It is thus important that everyone follow regulations aimed at avoiding interfering with other users. Amateurs must pass a licensing test to assure that they know these regulations and that they can operate their equipment properly. Many countries also require a basic knowledge of electronics and radio technology. Usually, countries grant several licences, limiting mainly the power at which the transmitter can operate. Countries license amateurs in accordance with an international treaty. Many local ham radio clubs offer courses that prepare amateurs to take the licensing test.

History. Amateur radio began during the early 1900's. In 1901, the Italian inventor Guglielmo Marconi successfully transmitted radio signals across the Atlantic Ocean from England to Newfoundland. Marconi's feat encouraged many people to set up their own radio stations and begin communicating with each other over the airwaves.

By 1912, there were so many radio stations on the air that a radio law became necessary to prevent interference. Amateur and other private stations were restricted to short-wave frequencies, which were considered of little value. But amateurs were soon sending messages from place to place, showing the value of short-wave radio for long-distance transmission.

Amateurs pioneered the development of radio in many other important ways. In 1919, a ham named Frank Conrad used his station in Pennsylvania, U.S.A., to transmit recorded music for the entertainment of people in the area, who listened on small crystal sets. This use of an amateur station helped lead to commercial radio broadcasting. In the late 1930's, a U.S. radio amateur named Grote Reber built the first radio telescope with a dish aerial and received radio noise from outer space (see **Radio telescope**). In 1961, the first amateur radio satellite, *Oscar 1,* was launched. This was also the first nongovernmental, noncommercial satellite. The first direct satellite communication between the Soviet Union and the United States took place via the *Oscar 4* amateur radio satellite in 1965.

See also **Radio; Morse code; Marconi, Guglielmo.**

Radio announcer. See **Radio** (Broadcasting services).

Radio astronomy. See **Astronomy** (Observing with telescopes; History: The development of radio astronomy); **Jansky, Karl G.**

Radio control. See **Remote control** (Kinds of remote control).

Radio Free Europe/Radio Liberty (RFE/RL) is a nonprofit corporation made up of two radio networks that broadcast to countries in eastern Europe and the former Soviet Union. The United States established the networks to oppose attempts by Communist governments to isolate their citizens from information about the world. In the late 1980's and early 1990's, Communists lost control of nearly all these governments of eastern Europe and, in 1991, the Soviet Union was replaced by a non-Communist Commonwealth of Independent States.

Today, Radio Free Europe broadcasts in a number of languages to Bulgaria, Estonia, Latvia, Lithuania, and Romania. Radio Liberty transmits to Russia, Ukraine, and other former Soviet republics. RFE/RL gets funds from the U.S. government through the Board for International Broadcasting.

People from the audience areas write and produce most RFE/RL programmes. Many of the programmes consist of news and news analysis, and they focus on current events in the audience countries. Other RFE/RL programmes describe cultural and religious activities and offer background information about economic, historical, and political matters.

Radio Free Europe began broadcasting to eastern Europe in 1950, and Radio Liberty started broadcasting to the Soviet Union in 1951. In 1976, the networks merged and formed RFE/RL, Inc. Its headquarters are in Munich, Germany.

Radio station. See **Radio** (The scope of broadcasting; Stations and networks).

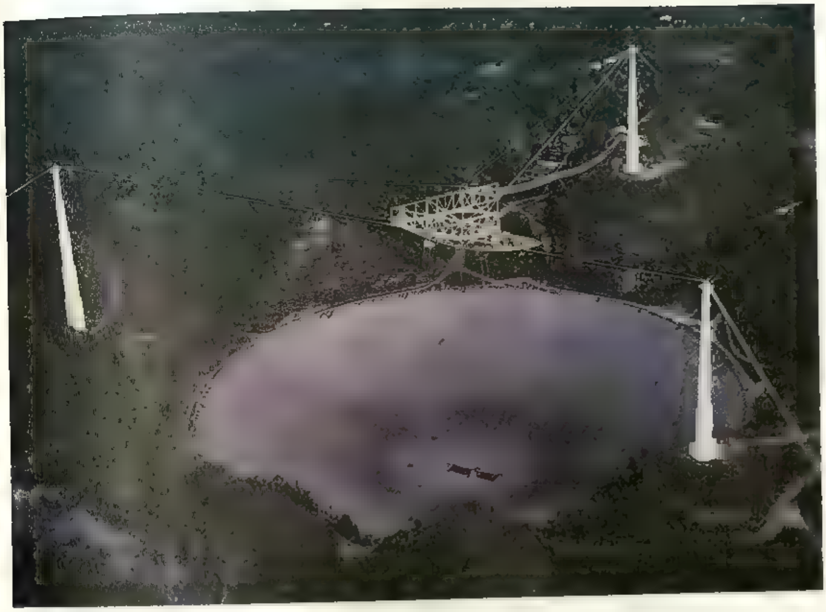
Radio telescope is an instrument that collects and measures faint radio waves given off by objects in space. It collects radio waves just as an optical telescope collects light. In fact, radio waves and light waves are forms of the same type of radiation, called *electromagnetic waves* (see **Electromagnetic waves**).

Many objects in space give off a variety of electromagnetic waves. Light waves can be seen with an optical telescope or with the unaided eye, but a radio telescope is needed to detect radio waves. Radio waves are much longer than light waves. As a result, a radio telescope must be much larger across than a light telescope to bring radio waves into sharp focus. Even so, individual radio telescopes cannot focus on an object so sharply as an optical telescope can.

A radio telescope can detect weaker electromagnetic waves than an optical telescope. As a result, a radio telescope can explore farther out into the universe. The best optical telescopes can detect objects only a few billion light-years away, except for very bright, distant objects. But radio telescopes can explore as far as 16 billion light-years—the greatest distance astronomers think that radio waves from objects in space can be detected.

Astronomers using radio telescopes have discovered objects in space never before imagined. These discoveries include *pulsars,* objects that send out precisely timed pulses of radio waves; and *quasars,* extremely luminous starlike objects that produce enormous amounts of radio waves. Radio telescopes have also found many types of molecules in space. These same types of molecules played an important role in the development of life on the earth.

How a radio telescope works. Most radio telescopes have a *parabolic* (bowl-shaped) reflector, also known as a dish aerial, to collect radio waves from space. These reflectors are made from wires or metal sheets. Motors in a telescope can turn the reflector toward any source of radio waves in the sky. The reflector



A giant radio telescope stands in the hills near Arecibo, Puerto Rico. The telescope's reflector "dish" has a diameter of 305 metres. Aluminium panels cover the inside of the reflector. These panels reflect radio waves coming from space into the aerial suspended above the reflector.

focuses these waves on a small radio aerial that changes them into an electric signal.

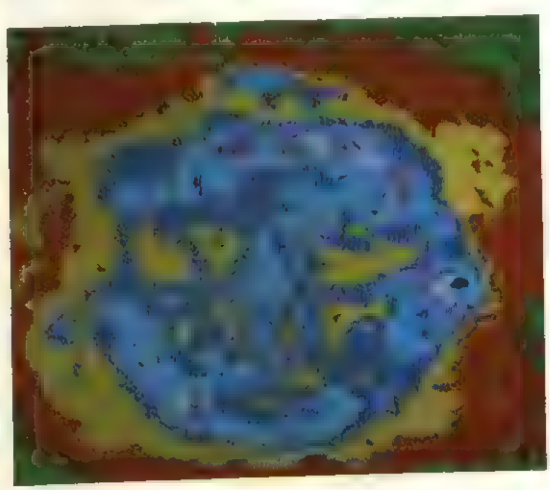
A radio receiver takes the signals from the aerial and tunes in only the signals that the astronomer wishes to observe. The receiver *amplifies* (strengthens) the signals and then records them. The signals may be recorded as wavy lines on paper or as data on a tape. The tape is later analysed by a computer, which combines the signals from the receiver and uses them to draw a picture of the source of the radio waves.

Two or more radio telescopes can be connected to produce a sharper radio picture of an object than a single telescope can. Astronomers use the term *radio interferometer* for telescopes connected in this way. The longer the *baseline* (distance) between the telescopes, the better they can focus on an object.

Astronomers can make a *very long baseline interferometer,* sometimes using telescopes located on different continents. The telescopes observe the same object and record the radio signals from it. A computer later compares the signals. In this way, astronomers can produce pictures of radio sources that are about 1,000 times as sharp as images that are produced by light telescopes.

An important interferometer, the Very Long Baseline Array (VLBA), was completed in 1993. The system con-

The Very Large Array (VLA) telescope, near Socorro, New Mexico, U.S.A., is the world's most powerful radio telescope. It consists of 27 reflectors, each measuring 25 metres in diameter. The Very Large Array was completed in 1980.



A computer graphic of an exploding star was created from radio waves collected by the Very Large Array telescope in New Mexico, U.S.A. This image shows a star that was seen to explode about 400 years ago in the constellation Cassiopeia.

Radiocarbon half-life

Half the radiocarbon in an object *decays* (breaks down by releasing particles) about every 5,700 years. This period is the *half-life* of radiocarbon. Newly cut wood retains most of its radiocarbon. After 5,700 years, half the radiocarbon disappears. After about 11,400 years, a quarter remains.

sists of 10 reflectors located across the United States from Hawaii to the Virgin Islands. Scientists expect the VLBA to provide the sharpest radio images ever produced.

Many radio telescopes can also send powerful radio waves to the moon and the planets. The telescope then picks up the radio echoes coming back from the moon or planet. Astronomers call this technique *radar astronomy* because it operates on the same principle as radar (see **Radar**). By studying the radio echoes, they can measure the distance to the moon or planet. Astronomers can also use the echoes to make a map of the moon or planet that shows details as small as 274 metres wide.

History. An American engineer, Karl G. Jansky, discovered radio waves from space in 1931. In the late 1930's, Grote Reber, an American amateur radio operator, built the first radio telescope.

In 1957, the British astronomer Sir Bernard Lovell built the first giant radio telescope. The reflector of this telescope, at the Jodrell Bank Observatory in Manchester, England, has a diameter of 76 metres. The world's most powerful radio telescope, called the *Very Large Array* (VLA), is located near Socorro, New Mexico, U.S.A. It consists of 27 reflectors, each measuring 25 metres in diameter. In the mid 1990's, work started in India on a project to construct the world's largest radio telescope.

See also **Jodrell Bank Observatory; Jansky, Karl G.; Lovell, Sir Bernard.**

Radio wave. See **Electromagnetic waves; Radio** (How radio works; diagrams).

Radioactive fallout. See **Fallout.**

Radioactivity. See **Radiation.**

Radiocarbon, or carbon 14, is a radioactive isotope of carbon. It has an atomic weight of 14 and is heavier than ordinary carbon, which has an atomic weight of 12.011. Radiocarbon is used to determine the age of fossils and other kinds of ancient objects. Researchers also use it to study certain biological processes.

In nature, radiocarbon forms when high-energy atomic particles called *cosmic rays* smash into the earth's atmosphere. Cosmic rays cause atoms in the atmosphere to break down into electrons, neutrons, protons, and other particles. Some neutrons strike the nuclei of nitrogen atoms in the atmosphere. Each of these nuclei absorbs a neutron and then loses a proton. In this way, a nitrogen atom becomes a radiocarbon atom.

All living things contain radiocarbon. Plants absorb radiocarbon from the carbon dioxide in the air. Human beings and other animals take in radiocarbon chiefly from the food provided by plants.

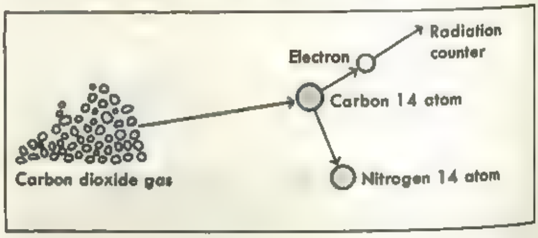
Radiocarbon dating is a process used to determine the age of an ancient object by measuring its radiocarbon content. This technique was developed in the late 1940's by Willard F. Libby, an American chemist.

Radiocarbon atoms, like all radioactive substances, *decay* (break down by releasing particles) at an exact and uniform rate. Half of the radiocarbon disappears after about 5,700 years. Therefore, radiocarbon has a *half-life* of that period of time (see **Radiation** (Radiation and radioactivity)). This steady decay at a known rate enables scientists to determine an object's age.

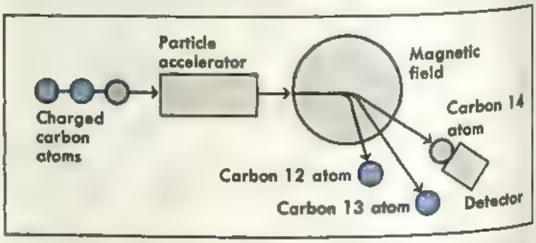
In one method of radiocarbon dating, scientists burn a piece of the object and convert it to carbon dioxide gas. The carbon dioxide is purified, and the amount of radiocarbon in the purified carbon dioxide is measured with *radiation counters*. These instruments detect the electrons released by the radiocarbon atoms as the

Radiocarbon dating

Scientists determine the age of an ancient object by measuring its radiocarbon content. This process is called *radiocarbon dating*. Two methods of radiocarbon dating are described below.



In the traditional method, a piece of the object is burned and converted to carbon dioxide gas. Radiocarbon (carbon 14) atoms in the gas release electrons as the radiocarbon changes into nitrogen 14. *Radiation counters* detect the number of electrons given off, which determines the object's radiocarbon content.



In a newer method, a *particle accelerator* fires charged atoms originally from a small piece of the object into a magnetic field. The field deflects and separates the various carbon atoms by their weight. Then a *detector* counts individual carbon 14 atoms to determine the object's radiocarbon content.

atoms change back into nitrogen atoms. The number of electrons emitted indicates the radiocarbon content.

Another method of radiocarbon dating involves the use of certain types of *particle accelerators* instead of radiation counters (see **Particle accelerator**). An accelerator enables scientists to detect and count directly the individual radiocarbon atoms in an extremely small portion of an object.

After scientists measure an object's radiocarbon content, they compare it with the radiocarbon in tree-rings whose ages are known (see **Tree** [diagram: How a tree reveals its history]). This technique enables them to compensate for small variations of radiocarbon content in the atmosphere at different times in the past, and so to calculate an object's date more precisely.

Radiocarbon in biology. Radiocarbon is used as a "tracer" to study various complex biological processes. In such research, scientists substitute a radiocarbon atom for an atom of a carbon molecule. Then they use a radiation counter to trace the path of the radiocarbon atom through a chemical reaction in an organism.

See also **Archaeology** (Dating).

Radiochemistry is a field of chemistry that involves the study of radioactive elements. It also deals with the production, identification, and use of such elements and their isotopes, and has benefited archaeology, biochemistry, and other scientific fields. Radiochemical techniques are often used in medicine to help diagnose disease and also in various environmental studies.

A few radioactive elements, such as thorium and uranium, occur in nature. Others are created artificially. They can be produced in devices called *particle accelerators* by bombarding nonradioactive elements with high-energy particles. Elements also can be made radioactive in nuclear reactors by exposing them to large numbers of neutrons.

The isotopes of radioactive elements are called *radionuclides* or *radioisotopes*. They are widely used as *tracers* in certain kinds of research, especially the study of complex biological processes. This type of study involves tracing radionuclides through chemical reactions in organisms. The tracing is done with Geiger counters, proportional counters, and other detection devices.

A radionuclide is produced in minute quantities, and so it tends to *plate out* (accumulate) on the walls of its container before it can be used. This is prevented by adding a *carrier element* (nonradioactive element) to it.

Another important radiochemical technique is called *neutron activation analysis*. In this method, an object is exposed to neutrons, causing some of the elements in the object to become radioactive. These elements then emit radiation of certain energies. One of the uses of this method is the verification of the authenticity of old paintings. The paint used in old works of art differs in composition from the paint in recent paintings, and so it gives off different radiations.

Radiogeology is the science that deals with the relation of radioactivity to geology. Geologists can determine the age of rocks, fossils, and other objects by measuring the radioactive elements in them.

The earth, the waters of the oceans, the air we breathe, and all living things contain small amounts of radioactivity. This radioactivity is caused by (1) the radioactive elements uranium and thorium, and their decay products; (2) radioactive potassium; (3) small amounts of less abundant radioactive elements, such as samarium and rubidium; and (4) radiocarbon, which forms when high-energy particles called *cosmic rays* strike nitrogen in the earth's atmosphere.

The rocks of the earth's surface contain an average of five parts of uranium per million parts of rock. Uranium has been in the earth since the earth was formed. It decays over time to become lead and helium. The rate at which a radioactive isotope decays is measured by its *half-life*—that is, the time required for half the atoms in the isotope to decay into another isotope. Lead isotope 206 is formed from uranium isotope 238, which has a half-life of about $4\frac{1}{2}$ billion years. Lead-207 is formed from uranium-235, which has a half-life of 700 million years. Scientists can measure the amounts of these isotopes in a rock sample and then calculate the rock's age from the ratio of lead-206 to uranium-238, the ratio of lead-207 to uranium-235, and the ratio of lead-206 to lead-207. Similar calculations can be made using other radioactive isotopes.

On the basis of lead-to-uranium ratios, scientists estimate that the age of the solar system is about $4\frac{1}{2}$ billion years. This figure agrees with the ages of meteorites and the oldest moon rocks as measured by the decay of other radioactive elements.

The decay of long-lived radioactive isotopes is like a great clock that measures time in millions or billions of years. The clock also has a "second hand" that measures time in thousands of years. This is radiocarbon, which has a half-life of 5,700 years. Analysis of radiocarbon content makes it possible to determine the age of wood, bone, and other once-living materials.

See also **Radiation; Radiocarbon.**

Radioisotope. See **Radiation; Isotope; Radiochemistry.**

Radiolaria. See **Protozoan** (Sarcodines).

Radiological warfare. See **Chemical-biological-radiological warfare.**

Radiology is the field of medicine that uses X rays and other means of creating images of the body to diagnose and aid in the treatment of diseases. It includes the use of such imaging techniques as computerized tomography (CT), fluoroscopy, magnetic resonance imaging, and positron emission tomography (see **Computerized tomography; Fluoroscopy; Magnetic resonance imaging; Positron emission tomography**). Medical procedures that involve *ultrasound* (high-frequency sound waves) are also part of radiology (see **Ultrasound**). Doctors who specialize in radiology are called *radiologists.*

Radiological imaging techniques help doctors to diagnose disorders by providing a view of the patient's internal structures. For example, a *radiograph* (X-ray picture) of the leg can reveal a fractured bone. A CT scan of the brain can detect a tumour or blood clot. In examinations of certain organs, the radiologist may administer a *contrast agent* to the patient. The contrast agent may be a barium mixture given orally to coat the lining of the bowel so that it is more clearly seen. A contrast agent consisting of an iodine mixture may be injected into a blood vessel to study arteries or veins.

Radiological procedures also aid in the treatment of certain disorders. For example, doctors use fluoroscopy, CT, or ultrasound imaging to guide *catheters* (small

Radiologists adjust a patient's position before taking an X-ray picture of his spine.

tubes) into a patient's body. This technique is used to drain obstructed ducts in the urinary tract and for many other treatments. *Radiation therapy,* one of the chief methods of treating cancer, is administered by radiologists. This type of therapy uses X rays or other forms of radiation to attack and destroy cancer cells. See **Cancer** (Radiation therapy).

See also **Computerized tomography; X rays.**

Radiosonde is an instrument used by meteorologists to take *soundings* (measurements) of the upper air. A radiosonde consists of devices that measure temperature, relative humidity, and air pressure, combined with a radio transmitter. The measuring instruments and transmitter are enclosed in a small box that is carried aloft by a balloon filled with helium or hydrogen.

The radio transmits the information recorded by the instruments to ground stations. In addition, a radio direction finder tracks the radiosonde to determine the speed and direction of the wind at various levels in the atmosphere.

See also **Weather** (Weather balloons); **Balloon** (Scientific uses).

Radiotelephone. See **Telephone** (Overseas service; Mobile telephone service).

Radiotherapy. See **Cancer** (Radiation therapy).

Radish is a plant grown for its fleshy root. The roots, also called *radishes,* are crisp and sharp-tasting. Radishes are eaten raw in salads or as an appetizer.

There are many *cultivars* (varieties) of radishes. Some are round or oblong, and others are shaped like icicles. They range in weight from less than 28 grams to more than 1 kilogram. Their colours include white, red, yellow, pink, purple, black, and a combination of red and white.

A radiosonde is used by meteorologists to measure atmospheric conditions. It relays the information to earth by radio.

Radishes grow best in cool weather, and they are able to withstand frost. The plants are ready for harvest 20 to 60 days after planting, depending on the cultivar. Most radishes grown in the Northern Hemisphere are harvested during March, April, and May. Many people plant radishes in home gardens, because of the plant's small size and quick growth. They are popular in school gardens and children's gardens because they are easy to grow.

Scientific classification. The radish plant belongs to the mustard family, Cruciferae. Its scientific name is *Raphanus sativus.*

Radishes are plants with crisp, sharp-tasting roots. Several varieties of radishes are shown above.

Radium was discovered by the French physicists Pierre and Marie Curie. The husband-and-wife team and a co-worker isolated the radioactive element in 1898.

Radisson, Pierre Esprit (1640?-1710?), was a French explorer and fur trader. He and his brother-in-law, Médard Chouart, Sieur des Groseilliers, were probably the first white people to explore the area north and west of the Great Lakes of North America.

Radisson was born in France. He came to what is now Canada as a boy. Iroquois Indians captured him in about 1651, but he escaped from them approximately two years later. About 1660, Radisson and Groseilliers explored the Lake Superior area. After quarrelling with the French over fur-trading rights, the two men went to England in 1665. Radisson and Groseilliers persuaded a group of English merchants to support a trading expedition to Hudson's Bay. This trip led to the establishment of the Hudson's Bay Company, an English fur-trading firm, in 1670. Radisson worked for the company from 1670 to 1675. He then returned to France. In 1684, he rejoined the Hudson's Bay Company. Radisson settled in England in 1687.

Radium is a chemical element with symbol Ra. It is a highly radioactive, metal. It occurs chiefly in uranium and thorium ores. The French physicists Marie and Pierre Curie and a co-worker, Gustave Bémont, discovered radium in 1898 while processing pitchblende, a uranium ore. See **Curie, Marie S.; Curie, Pierre.**

Before the mid-1950's, radium was widely used for treating cancer. It also was a key ingredient in fluorescent paint used for watch and instrument dials. Today, safer and cheaper sources of radiation have replaced radium for most medical and industrial uses. These sources include the isotope cobalt 60, particle accelerators, and X-ray machines.

Radium releases large amounts of high-energy radiation, which can be harmful to human health. The element resembles calcium chemically, and so it tends to accumulate in the bones after being absorbed by the body. The radiation given off by radium bombards the bone marrow and destroys tissue that produces red blood cells. It also can cause bone cancer. In the past, some workers who handled radium in factories that produced fluorescent watch dials died because they had absorbed the radioactive material. However, under normal conditions, there is almost no danger of absorbing hazardous amounts of radium because it occurs in such tiny quantities in the environment.

Properties. Radium is silver-white. Its atomic number is 88. Radium is the heaviest member of the group of elements called *alkaline earth metals* (see **Element, Chemical** [Periodic table of the elements]). Radium has at least 26 isotopes, all of which are radioactive. Radium has a mass number of 226.025. Radium melts at 700 °C, and it boils at 1140 °C. The element has a density of 5 grams per cubic centimetre at 20 °C.

How radium forms and breaks down. Radium is constantly being formed in nature by the *radioactive decay* of uranium. During radioactive decay, uranium 238, the heaviest isotope of uranium, emits radiation in the form of *alpha particles, beta particles,* and *gamma rays.* In doing so, uranium 238 becomes uranium 234, which later changes into thorium 230. This *unstable* (radioactive) isotope, in turn, breaks down into radium 226.

Concentrations of radium in nature are low because its isotopes disintegrate continually. Radium 226 decays into an unstable isotope of a heavy gas called radon and eventually into a stable isotope of lead.

Related articles in *World Book* include:

Cobalt	Radon
Particle accelerator	Transmutation of elements
Pitchblende	X rays
Radioactivity	

Radnorshire (pop. 23,200) was a local government district in central Powys, Wales. From 1974 to 1989, Radnorshire was known as Radnor. The district is rural. Bleak moorlands contrast with beautiful river valleys, such as that of the Wye. Dairy farming, sheeprearing, and tourism are important in the district. Pony trekking, hiking, and fishing attract many visitors. Llandrindod has carpet making and the town of Rhayader has a pottery.

See also **Powys.**

Radon is a radioactive element. Its chemical symbol is Rn and its atomic number is 86. Radon is a heavy, odourless gas produced by the radioactive *decay* (breakdown) of radium. Radium, in turn, is produced by the radioactive decay of uranium. Radon is released into the atmosphere from soil and rocks. It leaks into houses through the cracks in basement floors and walls. Highly concentrated radon can cause lung cancer if inhaled in large quantities. Outdoors, however, radon is diluted to safe levels.

The concentration of radon in a building depends largely on the type of construction and the materials used. New energy-efficient buildings, which keep in heated or cooled air, can also trap radon. In areas with a high natural concentration of radon, health hazards can be reduced by sealing cracks in foundation walls and floors; by installing a gas vent below the foundation; and by bringing in outside air to improve ventilation.

Radon is an inert element and does not react readily with other chemicals. But it can combine with fluorine and a few fluorine compounds. It may be condensed to a liquid that freezes at −71 °C and boils at −61.8 °C. Radon has 28 known isotopes, 3 that occur in nature and 25 that are produced in nuclear reactors. Its most stable isotope has an atomic weight of 222 and a *half-life* of 3.82 days (see **Radioactivity** [Half-life]). Friedrich E. Dorn, a German chemist, discovered radon in 1900.

Quentin McAdam (about 1810), an oil painting on canvas. Yale Center for British Art, Connecticut, U.S.A.

A Raeburn portrait shows the bold brushstrokes and dramatic lighting effects that are typical of the Scottish painter's style.

Raeburn, Sir Henry (1756-1823), was the leading Scottish portrait painter of his day. Raeburn painted straightforward portraits that captured the character of the subject. Most of his subjects were fashionable and upper-class Scottish people. Raeburn rarely sketched his subjects before painting them. Instead, he worked directly on the canvas, using bold, vigorous brushstrokes. Many of his portraits show strong colour contrasts and dramatic lighting effects.

Raeburn was born in Edinburgh and lived there most of his life. In 1785, Raeburn met Sir Joshua Reynolds, an English portrait artist. He was influenced by Reynolds' style, but painted in a more romantic manner. Raeburn became president of the Edinburgh Society of Artists in 1812, and a member of the Royal Academy in 1815. He was knighted in 1822 "in recognition of his distinguished merit as a painter."

Rafferty, Chips (1909-1971), was an Australian film actor. He appeared in almost every major film made in Australia from *The Overlanders* (1947) and *Eureka Stockade* (1948) to *They're a Weird Mob* (1965) and *Wake in Fright* (1969). Rafferty also produced films. He was born John William Goffage in Broken Hill and spent four years as a flying officer with the Royal Australian Air Force in World War II (1939-1945). The image he portrayed in many of his acting roles was that of the genuine, down-to-earth Australian.

Raffia is a fibre made from the leafstalks of certain varieties of palm trees. One of these palms, the *Raphia ruffia,* grows abundantly on the northeastern coast of Madagascar. Another, the *Raphia taedigera,* grows on the islands of Japan. Residents of Madagascar make clothes from raffia fibre, and weave baskets, mats, and small fancy bags from it. Raffia was once used in greenhouses to protect plants from cold and to tie buds and grafts. But today, artificial fibres are used. Raffia is used in schools for weaving baskets and other products. See also **Basket making**.

Raffles, Sir Stamford (1781-1826), an official of the British East India Company, was the founder of modern Singapore. In 1819, he gained the rights to establish a port in a treaty with Temenggong Abdul Rahman, the local chief, and Sultan Hussein, the ruler of Johor. By making Singapore a duty free port, he attracted ships wishing to exchange cargo. The success of the port brought thousands of immigrants to Singapore. He introduced the first town planning and guidelines for buildings. His work laid the foundation for an ordered development into a multiracial town, with certain areas set aside for different communities, for commerce or for government offices. Between 1819 and 1824, he spent three periods in Singapore, each lasting a few months, during which he announced laws, among which were those that banned slavery and gambling. He established the "Institution", a college for the education of the local people. It survives to this day as the Raffles Institution.

Thomas Stamford Raffles was born on board the merchant ship *Ann* off Port Morant in Jamaica. He entered the service of the British East India Company at the age of 14. His first posting to Asia was to Penang, in Malaya, in 1805, as an assistant secretary. In 1811, he accompanied a British military expedition to Java, which at that time was under Dutch control. The British occupied Batavia (now Jakarta) without a struggle, and Raffles was appointed lieutenant governor. He completely reformed the administration of Java before ill-health forced him to return to England in 1816.

In 1818, Raffles was appointed lieutenant governor of the British portion of Sumatra. In 1819, during his term of office in Sumatra, he established the island as a thriving port. In 1824, he was recalled to Britain for consistently disregarding government orders.

Raffles was one of the few Europeans of his time to study the language, history, and culture of the Malays. His two volume *History of Java* published in 1817 won him a knighthood. He was also a noted naturalist. In Sumatra, he and his friend, Joseph Arnold, discovered the *Rafflesia-Arnoldii,* a gigantic flower measuring 80 centimetres in width (see **Rafflesia**). During his time in Asia, Raffles gathered vast collections of plants and animals and Malay folk artefacts for the East India Company Museum. He founded the Zoological Society in London in 1826.

Rafflesia is the name of a small genus of plants which have huge flowers but no leaves or stems. The flowers grow as parasites on the stems and roots of several Cissus shrubs in Malaya. The giant rafflesia produces the largest flowers of any known plant. They can grow to 80 centimetres wide. The stamens and pistils of the rafflesia grow on separate flowers, and require some agent to pollinate them. The flowers have five wide, fleshy lobes and usually have a bad odour.

Scientific classification. The rafflesia belongs to the rafflesia family, Rafflesiaceae. The giant rafflesia is classified as *Rafflesia arnoldii.*

See also **Flower**.

Rafts were one of the earliest forms of water travel. In 1947, Thor Heyerdahl of Norway and a five-member crew sailed a wooden raft called the *Kon-Tiki, left,* 6,920 kilometres from South America to eastern Polynesia. The *Kon-Tiki* was a copy of the rafts that the ancient peoples of South America had used. Heyerdahl believed that they had made a similar voyage and had settled Polynesia.

Rafsanjani, Ali Akbar Hashemi, (1934-), was elected president of Iran in 1989. He was reelected in 1993. Rafsanjani succeeded Ali Khamenei, who became Iran's spiritual leader after the death of Ayatollah Ruhollah Khomeini. Rafsanjani is considered a moderate.

Hashemi Rafsanjani

Rafsanjani was born in a village near Kerman in eastern Iran. He became a follower of Khomeini in the 1950's, while studying theology in Qom. In the 1960's and 1970's, Rafsanjani participated in the campaign organized by Iran's clergy against the government of Shah Mohammad Reza Pahlavi. In 1979, Khomeini became the chief political figure of Iran after his followers had overthrown the shah. He appointed Rafsanjani to the Revolutionary Council, which governed Iran until 1980. Rafsanjani was elected to parliament in 1980 and served as its speaker until 1989. He held other important posts, including minister of the interior and acting commander in chief of the armed forces.

Raft is one of the simplest kinds of watercraft. It may be made of logs lashed together with ropes, or of any other material that floats. Rafts are usually square or rectangular, but they may be built in any shape. Poles, paddles, or sails can be used to propel a raft. Sometimes river and ocean currents alone move a raft to its destination. Most modern rafts used for recreational purposes are inflatable and are made of nylon fabric coated with a synthetic rubber called *neoprene* (see **Rafting**).

Early people built rafts of logs, reeds, or inflated animal skins lashed together with vines. Such rafts provided a means of using the currents of waterways. A raft drifting with a river's current could carry passengers and goods to the sea. Ancient seaports were frequently located at the mouths of rivers, where they could easily receive goods from areas farther inland.

In 1947, Thor Heyerdahl of Norway and five companions drifted on the balsa-wood raft *Kon-Tiki* for about 6,920 kilometres. They sailed from Peru to the Tuamotu Islands in the central Pacific (see **Heyerdahl, Thor**). In 1963 and 1964, 70-year-old William Willis of the United States sailed for 17,461 kilometres on the *Age Unlimited,* a steel pontoon raft. He went from Peru to Australia—with a stop in Samoa for repairs—in 204 days.

Rafting is an outdoor recreational activity in which small groups of people float down a river on rafts. Rafting provides an opportunity to enjoy scenic areas in a fresh way. Many people enjoy the adventure and challenge of rafting on rivers with *white water* (rapids). A raft

Rafting on *white water* (rapids) is an exciting challenge. The crew uses paddles to steer the craft through the swirling waters.

trip can last only a few hours, or it can be combined with a camping trip that lasts several days.

Most rafts are 3.7 to 5 metres long. The most common kind are inflatable rafts made of nylon fabric coated with *neoprene* (synthetic rubber). The shape resembles a rectangle with rounded corners. Most crews consist of six people. They steer the raft with paddles.

The raft is one of the oldest forms of transportation. However, rafting did not become a popular leisure-time activity until the 1980's.

Ragtime is a kind of music that uses strongly syncopated melody and a regularly accented accompaniment. Originally a *piano rag* had a regular rhythmic bass for the left hand and a highly complex melody for the right hand. The term *ragtime* gradually came to be applied to early forms of jazz, such as Irving Berlin's "Alexander's Ragtime Band."

See also **Jazz.**

Ragweed is the name of several weeds which are common in North America. They grow along roadsides, in fields, and on waste ground. Related plants are found in Central and South America, and there is one Mediterranean species. Many people are allergic to ragweed pollen. It is produced in great amounts and spread by the wind.

The common ragweed usually grows 30 to 90 centimetres high. Ragweed sprouts quickly along roadsides and in fields. Many people are allergic to ragweed pollen.

The *common ragweed* is a coarse annual plant with finely divided leaves. Common ragweed usually grows to between 30 and 90 centimetres high. The small, hard fruit has short, sharp spines near its end. The Mediterranean ragweed is strong-smelling and is used to flavour liquors.

Scientific classification. Ragweeds are in the family Compositae (Asteraceae). The common ragweed is *Ambrosia artemisiifolia.* The Mediterranean species is *A. maritima.*

Ragwort is the name of many species of plants with flat-topped clusters of small yellow-rayed flowers. The *common ragwort* of Europe grows to just over 1 metre high. It has deeply lobed *pinnate* (feather-like) leaves and grows on sand dunes and other dry grassy areas. *Oxford ragwort,* a southern European plant, was first grown in England in the Oxford Botanic Gardens, but has since spread by colonizing dry railway embankments. *Groundsel,* a common weed, is a kind of ragwort. Some ragworts with showy flowers are cultivated and are best known by their Latin name *Senecio.*

Scientific classification. Ragworts belong to the family Compositae (Asteraceae). They are genus *Senecio.* The common ragwort is *S. jacobea,* Oxford ragwort is *S. squalidus* and groundsel is *S. vulgaris.*

Raikes, Robert (1735-1811), an English publisher, first developed Sunday schools on an extensive scale. Many children in his home city, Gloucester, worked six long days in the factories and had no chance for education. He opened his first Sunday school there in 1780. Sunday schools helped train children in reading and arithmetic as well as in the Bible, because there were no state schools. Before Raikes died, his system had spread throughout England.

Rail is the common name of a family of marsh birds that live throughout most of the world. The family includes the rails proper, the gallinules, and the coots. The birds called rails live in grassy marshes. They run swiftly over the mud, seeking worms, insects, snails, and floating seeds. Rails vary in length from 13 to 50 centimetres. They have long, narrow bodies, short wings and tails, long legs and toes, and loose plumage of mixed black, brown, and grey feathers. A rail's shape helps it slip through reeds and grasses. Rails migrate long distances. However, the birds are seldom seen in flight except when chased from cover. They build nests of grasses on the ground or among rushes over water. They lay from 6 to 15 buffy-white eggs, speckled with reddish-brown.

Rails are noisy birds. They have a variety of calls, from grunts and squeals to whistles. They often can be heard at night and early in the morning. The *water rail* is the common rail of Europe, North Africa and large parts of Asia.

Scientific classification. Rails make up the rail family, Rallidae. The water rail is *Rallus aquaticus*

See also **Coot; Gallinule.**

The rail is a swift, slender bird that can run quickly through reeds and other marshland vegetation.

The world's fastest passenger train is France's TGV (*train à grande vitesse*). The TGV above travels between Paris and cities in western France at a speed of 300 kilometres per hour. Trains once carried most of the passenger traffic between cities. But today more people use cars or aeroplanes, and most railways get most of their income from carrying freight.

Railway

Railway is one of the most important means of transportation. Every day, thousands of trains speed along railway tracks throughout the world. Some trains carry passengers. Others carry coal, grain, machinery, timber, and other products on which people depend. Only aeroplanes provide a faster means of public transportation than do railways. And only ships carry heavier cargoes for longer distances. The fastest passenger trains reach speeds of up to 370 kilometres per hour (kph). A freight train can carry thousands of tons of goods across a continent.

Railways use two steel rails to guide trains along a permanent route. Trains therefore are not steered, unlike aeroplanes, cars, and ships. Powerful diesel-electric or electric locomotives move most trains along the track. But older steam locomotives still pull trains in some parts of the world.

Almost every country has at least one railway. Some railway lines extend only a short distance. The world's longest rail line is in Russia. It extends about 9,010 kilometres and connects Moscow and Vladivostok in the extreme southeast of the country. Laid end to end, the tracks of the world's main railway routes would stretch about 1,207,000 kilometres—about $3\frac{1}{4}$ times the distance from the earth to the moon.

The word *railway* refers not only to a method of transportation but also to the organizations that provide rail transportation. In most countries, the central government owns all or most of the railways. A government agency or government-owned corporation operates these railways.

The first public railways began in England in the 1820's and 1830's. They used steam engines to pull wagons loaded with freight or coaches loaded with passengers. Rail transport grew rapidly and played an important part in Britain's industrial development in the 1850's. By the mid-1800's, other countries also had steam-powered railways. During the late 1800's and early 1900's, thousands of steam trains puffed their way across the countryside, carrying freight and long-distance passengers. The first railway across western North America was completed in 1869 and helped open the American West to settlers.

Over the years, railways have faced ever-increasing competition from other forms of transportation. In most countries, the central government supports the railways. In India, whose railway network is the largest in Asia, the state-owned system has continued to expand since the 1950's. By the 1990's, passenger and freight services had increased to three times what they were after World War II (1939-1945).

In countries where there is little government support for railways, such as the United States, a number of railway companies face serious financial difficulties. In the United Kingdom, where there is some government funding, railway companies have not been able to invest sufficiently in new rolling stock and modernization programmes. Environmental groups also oppose the building of new railway links. However, in many large cities, new commuter railways have been developed to reduce the traffic congestion caused by commuters going to work by car.

How railways serve the public

Railways provide two main types of service: (1) passenger service and (2) freight service. The importance of each type varies from country to country.

Passenger trains. Railways operate two main types of passenger trains: *commuter trains* and *intercity trains.* Commuter trains carry passengers between large cities and the surrounding suburbs. Most of these trains are equipped with *coaches* only. Coaches provide seating for passengers but do not ordinarily offer any extra services, such as meals or refreshments. Intercity trains make much longer journeys than most commuter trains do. The longest intercity runs cover great distances and take several days to complete. As a result, many intercity and international passenger trains have special cars, such as *dining cars* and *sleeping cars,* in addition to coaches.

Since the 1940's, the number of rail passengers in many industrial countries has declined sharply as more and more people travel by car and aeroplane. In some countries, however, passenger trains have not faced such strong competition from other forms of transportation. People in China, India, Japan, and most European countries still rely heavily on trains for travel between cities. The railway systems the most intensively used by passengers worldwide are those of Japan and Switzerland.

Commuter trains. A large percentage of all rail passengers travel on commuter trains. Each working day, these trains carry hundreds of thousands of suburban residents to and from work in such large cities as London and New York City. Commuter trains also serve Calcutta, Johannesburg, Moscow, Paris, Tokyo, and many other cities throughout the world. Some intercity trains also serve commuters.

It takes as many as 1,000 private cars to carry as many commuters as one commuter train can carry. Commuter trains thus help relieve rush-hour traffic jams on city roads. By reducing the number of vehicles in use, commuter trains help conserve fuel. In addition, such trains help reduce air pollution caused by car exhaust fumes.

Intercity trains. Some countries have unusually fast, efficient intercity passenger trains. Many Japanese trains, for example, travel at an average speed of more than 160 kph. The fastest passenger trains in the world operate in France. These trains travel up to 269 kph between Paris and Lyon and up to 330 kph between Paris and cities in western France. High-speed trains also serve cities in the United Kingdom and other European countries. Many of the Japanese and European high-speed trains offer a number of luxury services, including barber and beauty shops, gift shops, telephones, and meals served at the passengers' seats.

In Britain, a journey by passenger train involves work by many people in various departments. The traveller first finds the time of a train from a timetable or an inquiry office. He or she then buys a ticket at a ticket office and perhaps reserves a seat at the same time. The traveller may have tea and a sandwich in a station buffet. Some of the larger railway stations have fast-food cafes and restaurants. A member of the traffic department announces the trains. A railman supervises the departure of each train. At a large station, the area manager has

Catering facilities on intercity trains include buffet cars, *above left,* which provide snacks and light meals. In restaurant cars, a chef, *above right,* cooks meals, including breakfasts.

several hundred staff working in shifts throughout the day and night.

The train may be powered by a diesel or electric locomotive provided by the motive-power department. Workers from this department have cleaned and fuelled the locomotive and prepared it for the journey. Mechanical and electrical fitters have examined the locomotive and made sure that it is in a sound condition. The driver and a guard have read notices telling them of temporary speed restrictions, engineering work, and other points to note along the route. The coaches have been washed and cleaned. If there is a dining car or a buffet, it has been stocked with food and drink, and the chef is preparing the next meal.

The guard instructs the driver to start the train. The guard's duty is to make sure the train is safe and to get it away on time. After that, the driver moves the train under the control of the signalmen in signal boxes along the line. The guard checks or collects passengers' tickets while the train is moving.

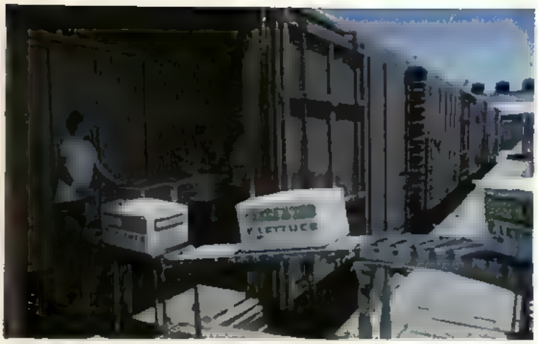
Freight trains. In many countries, most of the income earned by railways comes from carrying freight. Transport by rail is the cheapest form of transportation over land for long distances. The Soviet Union transports the largest amount of freight by train, followed by the United States and China. Trains are extensively used for the transportation of bulk goods, such as ore, coal, oil, and chemicals.

Railways have a wide variety of wagons and freight-handling equipment. Bulk materials, such as coal and ores, travel in open wagons with doors underneath or at the sides. Such wagons can be emptied quickly through these doors, or the whole wagon can be turned upside-down in a *tipper.* Powdered material, such as cement, travels in wagons whose bodies are pressurized steel containers. These wagons are loaded and unloaded by air pressure, the powder flowing in and out through pipes. In some countries, special wagons with two or three decks carry motor cars. Covered wagons protect goods that might be damaged by the weather, and some railways have open wagons that can be covered by a metal roll-top. Open wagons can also be covered by fabric sheets. Chemicals, milk, petrol, oil, and other fluids travel in tank cars. Perishable foods travel in refrigerator cars. Some foods, such as bananas, travel in heated vans to ensure they are ready to eat on delivery.

In the United States, many railways use road trailers instead of containers. The whole trailer is carried on a wagon. Trailers with rail wheels as well as road wheels have been used in the United States and are being considered in the UK. These trailers can run on roads or railways and hauled by locomotives at high speeds.

At one time, railways used to drop off or pick up wagons at nearly every station. But, today, railways run fast freight trains between limited numbers of railheads and sorting yards. Trucks collect and deliver the loads over a wide region. Most railways prefer to keep trains of wagons together as a complete unit. A coal train can be loaded and unloaded without coming to a complete stop.

Freight services. In the UK, most freight on the railways travels in full wagonloads. Varied wagons are joined to form a *Speedlink train.* A network of Speedlink trains connects major towns and cities. Many of these trains run at night.



Refrigerator cars are equipped to keep fruits, vegetables, and meats at the right temperature.

Much freight travels on *company trains,* each of which carries products or raw materials for one company. Company trains run direct between two terminals. Many of the terminals are private sidings at mines, factories, or other industrial areas. In Australia, all private mineral railways together transport about 150 million metric tons of raw materials, mostly iron ore for export. The extensive railways built in Africa to carry raw materials from the mines to the coast for export are now also being used for passenger service.

To attract more customers, railways in many countries have tried to improve their freight service. In the 1950's, for example, U.S. railways introduced *piggyback* service—the use of flatcars to carry truck trailers loaded with freight. Piggyback service attracted shippers because one train could carry many truck trailers for a fraction of what it cost to haul them individually by road. Today, U.S. railways carry hundreds of thousands of truck trailers each year and so have won back some of the business lost to trucking companies. Another type of piggyback service uses flatcars to haul large containers loaded with freight. The containers are transferred to the flatcars from specially designed ships or trucks.

Container traffic in the UK is carried by Freightliner trains that operate between set terminals. The containers are transferred to and from the terminal by road. Many of the containers are specially built for one type of freight. Smaller consignments of goods can be sent by train, using either the fast passenger trains or special trains for parcels. Mail is carried on passenger trains or on special trains under a contract with the Post Office. It is often loaded and unloaded by Post Office staff. Travelling sorting offices enable mail to be sorted during the journey. The Post Office has its own automatic underground railway in London.

What makes up a railway

A railway consists basically of a track along which locomotives pull trains of *cars* (passenger coaches or freight wagons). The track is made up of two steel rails fastened lengthwise to a series of wooden or concrete *sleepers.* The wheel-and-axle assemblies on locomotives

and cars are specially designed to run on a track. Each wheel has a *flange* (rim) around its inner edge. The flanges on each pair of wheels guide the wheels along the track. Trains use *points* to change over from one track to another. Points, also called *switches,* consist of short movable rails placed at intersections of rails. A common type of point is the *split switch* mounted at the beginning of a *turnout.* A turnout is a curved section of rails that allow a train to leave a track and to continue travelling on another track. Electric motors controlled from a signal box actuate points.

But a railway consists of much more than its basic features—tracks, locomotives, and cars. It also includes signal systems to control train traffic, stations to handle passengers and freight, *yards* to make up trains, and *shops* to repair locomotives and cars. A railway also includes workers who do hundreds of different jobs, from running trains to repairing tracks.

Rolling stock. This section discusses railway *rolling stock*—that is, locomotives and cars. It also describes how railway tracks are laid and how railway routes are planned.

Locomotives. Most trains are pulled by a locomotive at the head of the train. But some locomotives can push as well as pull. These locomotives are especially useful on commuter lines because they eliminate the need to turn a train around for a return trip at the end of a run.

Locomotives can be classified into two groups by the work they do. *Road locomotives* carry freight or passenger trains. *Shunting locomotives* move cars from track to track in railway sorting yards.

Most locomotives can also be classified into three groups according to how they are powered. *Diesel-electric locomotives* use oil-burning diesel engines to turn electric generators. The electric power produced by the generators runs the driving mechanisms that turn the locomotive's wheels. *Electric locomotives* work much as diesel-electrics do. But instead of producing their own electric power, they get it from wires suspended above the track or from an electrified third rail. *Steam locomotives* burn coal or fuel oil to produce steam. The force of the steam provides the power that runs the locomotive.

A few trains are powered by two other kinds of locomotives. *Gas-turbine electric locomotives* use the force of hot gases to run turbines, which in turn operate electric generators. As in diesel-electric locomotives, the electric power produced by the generators runs the trains. *Diesel-hydraulic locomotives* use diesel engines to produce energy that is transmitted to the driving mechanisms by means of fluids under pressure. See **Locomotive** and **Electric railway.**

Railways in most industrial countries operate both diesel-electric and electric locomotives. Steam locomotives are still used in China, India, and a few other countries.

Passenger and freight cars. Most railway cars carry either passengers or freight. Each one has a *coupler* at each end. This device links the cars together. Cars also have *air brakes,* which are connected to a master control in the locomotive (see **Brake** [Air brakes]).

On most passenger trains, the cars consist mainly of coaches. The majority of coaches have seats for 50 to 90 passengers. Double-decker coaches on some routes seat from 150 to 170 people. Some passenger-train cars provide card tables, refreshments, or other services that are not generally available on coaches. Other passenger-train cars include baggage cars; dining cars; and sleeping cars.

Freight cars differ in shape and size according to the freight they are designed to carry. They range from boxcars for carrying general freight to specially designed transporters for new cars. Many newer railway cars are similar to older types but have been redesigned to carry different kinds of freight.

Railways have greatly improved the safety of railway cars over the years. One of the chief improvements has been to reduce the danger from overheated *axle boxes.* On older cars, each end of an axle turns on solid surfaces enclosed in an axle box. A box may become overheated through lack of lubrication and so become a *hot-box.* A hot-box, in turn, may burn away the end of an axle and so cause a derailment. On newer cars, the use of roller bearings rather than solid surfaces at the ends of axles has helped reduce the number of hot-boxes. Railways have also installed electronic devices called *hot-box detectors* at various points alongside railway tracks. As trains pass by, the devices detect any hot-boxes. This information is electrically transmitted to a signalling centre. Workers at the signalling centre react to the information by sending out a crew to remove cars with hot-boxes from the train.

Railcars are railway cars equipped with a built-in power unit. Because these cars provide their own power, they do not need to be hauled by a locomotive. A railcar may be diesel-electric, electric, or gas-turbine electric.

Some railcars are equipped to carry passengers. These have seats and windows behind the power unit. Some passenger railcars haul one or more passenger coaches and so form *railcar trains. Metroliners,* the electric trains that run between New York City and Washington, D.C., are among the best-known railcar trains in the United States. Other familiar railcar trains include the fully automated Docklands Light Railway that operates in the newly developed docklands area of London. This railway opened in 1987.

Some self-propelled cars are designed for use in railway maintenance. Each carries equipment to do a particular job along a railway line. For example, some have track-laying machinery or machinery for inspecting or repairing tracks. Others carry such equipment as snowploughs or weed cutters.

Tracks. The rails and sleepers that make up railway track are laid along a *roadbed*—that is, land that has been prepared as a foundation for the track. The roadbed follows the route planned for a railway. *Main-line* routes link major cities. *Branch lines* extend between main lines and various places not served by main lines, such as small towns or industrial areas. Many main lines consist of two or more tracks laid side by side. Such *multiple track* allows trains to travel in opposite directions on the same line at the same time. Single-track lines must be equipped with *sidings* at various points

Train wheels and tracks

Trains ride on *flanged* wheels. A flange is a rim on a wheel's inner edge that guides the wheel along the track. The track consists of two rails supported by *sleepers.* Metal *fixings* spiked to the sleepers have a groove that, together with the spikes, holds the rails in place. The sleepers are anchored in a layer of *ballast* (gravel or crushed stone).

along the route. A siding is a short track alongside a main or branch line to which one of two meeting trains is switched until the other train passes.

The track and roadbed, together with such other railway structures as tunnels and bridges, are sometimes referred to as the *permanent way.* In addition to this, railways own a certain amount of land on both sides of the permanent way. This land and the permanent way make up a railway's *right of way.*

The rails and sleepers. Most sleepers are spaced about 53 centimetres apart. The sleepers average about 1,900 per kilometre. Two steel plates called *fixings* are spiked to the top of each sleeper, one near each end. Each plate has a groove that is shaped to hold the bottom of the rail. The groove and the spikes, which hook over the bottom of the rail, keep the rail firmly fastened to the sleeper.

The two plates must be the same distance apart on every sleeper so that they hold the rails the same distance apart all along the track. This uniform distance between rails is called the *gauge.* Every country has a *standard gauge* for all its main rail lines. Most countries also have this same standard gauge for most branch lines. In this way, any train can travel on almost any track in the country. But the standard gauge varies from country to country. Australia, New Zealand, and most European nations have a standard gauge of 4 ft. $8\frac{1}{2}$ in. (1.435 metre). Indian railways have three types of gauge—broad, metre, and narrow.

The roadbed and route. In building a roadbed, engineers use special instruments and machinery to make the land as smooth and level as possible. This process is called *grading.* Most roadbeds are covered with a layer of *ballast,* which consists of such materials as gravel or crushed stone. Ballast holds the sleepers in place and so helps keep the track stable. Ballast also helps distribute the weight of passing trains and gives them a degree of cushioning. Trains thus ride more easily than they would over bare ground. Ballast also promotes drainage of rain water and slows the growth of weeds.

Before constructing the roadbed, engineers plan a route with the least possible *gradient* and *curvature.* Gradient refers to the steepness of the land. Curvature refers to the number and sharpness of curves along the route. The ideal railway route lies across perfectly flat land. Track laid along such a route has little or no gradient or curvature. Freight trains can carry heavy loads along the track without difficulty, and passenger trains can travel at top speed. Steep gradients, on the other hand, prevent a train from carrying heavy loads or trav-

Cranes lift whole track sections into place, especially where railway points and other complex sections are being laid.

elling at high speed. If a route passes through hilly or mountainous country, engineers lay track around steep gradients instead of over them. The track thus has many curves. Curves reduce a train's speed but do not prevent it from carrying heavy loads.

A route through a mountain range might require so many curves that travel along the route would be extremely slow. Engineers therefore often build railway tunnels through some of the mountains. They also build railway bridges to span some of the deepest valleys. Tunnels and bridges are also built to extend railway routes under or across rivers and other bodies of water.

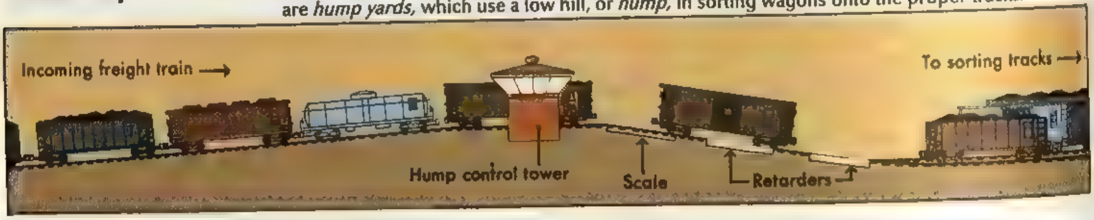
Freight operations. Freight trains are assembled in *sorting yards* at various railway terminals. A terminal may also have facilities for loading and unloading wagons and for repairing locomotives and wagons. After freight vehicles arrive at a sorting yard, they are sorted into groups according to their destination. All the vehicles in a group must be heading for destinations along the same route or along branches of this route. After a locomotive has been coupled to such a group of wagons, the unit becomes a freight train. Wagons heading for destinations off the main route must be switched to other trains along the way.

In the past, railway freight shipments frequently met long delays at sorting yards. They also met delays at *interchanges*—that is, at rail junctions where cars are switched from one railway to another. In addition, railways often had difficulty keeping track of cars that had to be interchanged several times.

To speed freight shipments, railways have improved their freight-handling methods in three main ways. First, they have modernized sorting yards. Second, they have simplified the work at interchanges. Third, and perhaps most important, the railways have developed computer systems for planning and monitoring their operations. In one such system, the computer generates a specific "trip plan" for each wagon. As the wagon moves in a train from its origin to its destination, its plan is checked at sorting yards to see that the wagon is moving on schedule. The shipper and the receiver of the wagon can then be notified when the wagon's delivery is expected.

How freight trains are made up

Freight trains are made up at *sorting yards,* which consist mainly of groups of parallel tracks. Each track is reserved for freight wagons that will make up a particular train. Most large sorting yards are *hump yards,* which use a low hill, or *hump,* in sorting wagons onto the proper tracks.



The hump has a single track up one side, *above left.* Partway down the other side, the track branches out into the sorting tracks. A shunting locomotive pushes an incoming train up the hump. As each wagon reaches the top, it is uncoupled and the proper points are opened. The wagon is weighed and rolls onto its assigned track. Most hump yards are automated.

Sorting wagons. A computer, *above left,* uses information about each wagon's destination and weight to open the points leading to the wagon's assigned track and to operate *retarders* in the downhill track, *centre.* The retarders slow the wagon so that when it reaches the sorting tracks, *right,* it is travelling just fast enough to couple automatically with the wagon ahead.

Traffic control

Railways use signals and various other means to control train traffic. The chief purpose of traffic control is to prevent accidents. But it also helps make railway operations speedier and more efficient.

Most railway signals consist of coloured lights alongside or over the track. Each colour has a different meaning. For example, red means *stop,* and green means *proceed.* At some places, *semaphore* signals are used instead of lights. A semaphore is a movable arm on top of a post. Each position of the arm gives a signal that corresponds to a coloured-light signal.

Most railways have adopted some form of the *block signal* system. This system is designed to keep a safe distance between trains travelling on the same track. In block signal systems, a railway line is divided into lengths of track called *blocks.* Only one train may be in a block at a time. Signals control entry to the block. When a train is in the block, the signals warn following trains to stop. No train may proceed from one block to the next without an all-clear signal. Block signals may be either *manual* (hand-operated) or *automatic.*

Manual block signal systems require operators at various points along the line to control the signals. Each operator is responsible for the movement of trains within one or two blocks and informs other operators by telephone or telegraph whether a block is occupied or clear. The possibility of human error makes manual signal systems less reliable than automatic systems.

Some manual block systems have *interlocking* controls—that is, the set of signals at the beginning of each block is electrically connected with the block signal controls in the preceding block. Interlocking controls also connect the block signals with all other signal and switch controls in the same block, such as those at junctions and sidings. When the block signals warn that a train is in the block ahead, all the connected signal and switch controls automatically lock in warning position. They cannot be moved from that position until the block signals show all clear. Interlocking systems reduce the danger of human error.

Automatic block signal systems. In an automatic block system, the signals are operated by an electric current, or *track circuit,* that flows through the rails. A train entering a block short-circuits this current, causing the signal that guards the block to turn red. As soon as the train leaves the block, the signal returns to all clear. Most automatic block systems have interlocking controls.

One of the most advanced signal systems is called *Centralized Traffic Control* (CTC). CTC makes use of automatic block signals for trains following one another on the same track. But all other signals and points on the line are controlled from a central control station. This station has one or more electric diagrams that show the present location of every train on a line. CTC operators study the diagrams to decide how to route the trains as safely and efficiently as possible. The operators direct train traffic by setting the necessary signals and points. CTC makes it possible for railways to eliminate most multiple track and use single tracks instead. If two trains are heading toward one another on the same track, a CTC operator switches one of the trains to a siding until the other passes. CTC also makes use of interlocking controls.

Other train controls. In addition to signal lights alongside their tracks, some railways have signals providing the same information on panels in their locomotives. These signals may also work in connection with certain safety devices. One such device is the *automatic train stop* (ATS). The ATS puts on a train's brakes automatically if the driver fails to notice a stop signal. Another safety device, called *automatic train control* (ATC), automatically controls a train's speed. If the driver fails to notice a caution signal, the ATC puts on the brakes to slow the train to the required speed. The device also stops the train if necessary.

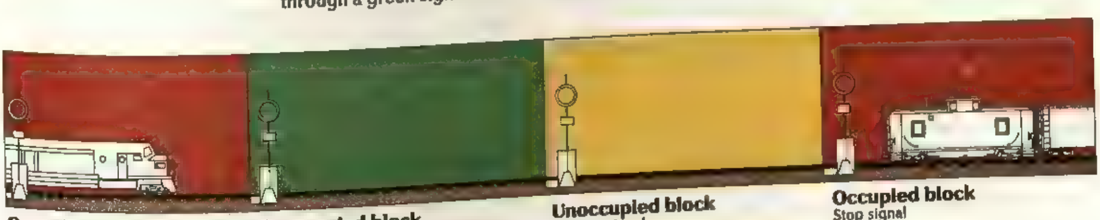
Many railways use advanced communications systems to help control the movement of trains along the tracks. Two-way radio systems on trains allow members of the crew to communicate from one end of the train to the other. More powerful two-way radio systems enable train crews to communicate with distant train yards and stations.

Modernization schemes

Since railways began their importance has been recognized by governments which either took them over or controlled their development. Early railways were profitable business. Today, competition from other forms of transport has cut their proportion of the total traffic, so they cannot finance the huge investment needed to keep rail systems up to date.

Automatic block signalling

Automatic block signals allow trains to follow one another safely on the same track. The track is divided into *blocks* about 1.5 to 3 kilometres long. An electric current flows through the rails and is short-circuited when a train is in a block. The short circuit causes the signal for that block to turn red and the preceding block signal to turn yellow. Other signals show green. A train may proceed through a green signal but must slow down at a yellow signal and stop at a red one.



A computer system like the one on the left enables a train dispatcher to closely monitor the movement of a train. The dispatcher uses the system to set signals and points so that the train can travel as quickly and safely as possible toward its destination.

Because railways provide an important, sometimes essential, social service, governments often provide financial assistance. Modernization depends on priorities. An innovation in one country may have been established earlier elsewhere. Most European countries had adopted air brakes on trains in the 1920's, but Britain did not begin changing from the vacuum brake system until the 1960's.

Different countries find different solutions to problems. Overcrowding on passenger trains can be eased by using double-decker coaches, but on British railways the smaller clearances make this impossible. On the suburban lines, extra coaches can be added to trains, and platforms of stations made longer. The capacity of the tracks can be increased by altering signalling and block lengths, which allows trains to follow one another more closely. Such measures require more centralized control, and the expense is justified only when traffic is very dense. In India, capacity is being increased by conversion of metre gauge tracks to broad gauge.

The most expensive form of modernization is the introduction of very high speed trains, which requires highly efficient trains, track and safety systems. High speed is, however, the single most attractive attribute of a railway if passengers are to be won back. The high-speed trains in France and Japan received massive investments, with all-new track. In Britain, less high speeds have been achieved, by easing curves on existing lines and fitting long welded rails on concrete sleepers. It is often worthwhile to have trains operated by one driver, who can also operate doors; this speeds up services by shortening station stops. The use of *push-pull* trains (one traction unit at each end) also saves time. It enables maximum use to be made of station space, and requires less staff, as well as reducing the number of trains needed to run a service. In the United Kingdom, push-pull trains are now used on both main lines from London to Scotland.

In the United States, railways cannot compete with airlines on very long-distance routes. But here too, high speeds, although not as high as those in Europe, have attracted passengers onto trains in the eastern states. The Americans excel in freight haulage, having invested heavily in modern technology and centralized control to maximize the use of single lines.

Railways around the world

North America. All railways in the United States are run by private companies, and earn 95 per cent of their income from freight haulage. Railways carry about 50 per cent of U.S. inter-city freight business. They maintain their share of this traffic by the application of modern technology in the efficient, speedy movement every day of 10,000 trains, averaging 2,000 metric tons each, over the greatest length of tracks in the world. Trains are hauled by multi-unit diesel-electric locomotives. Freight trains carry all kinds of goods, including bulk materials such as coal and iron ore, motor vehicles and loaded containers and road trailers.

Competition from road transport and especially from airlines has taken much of the long-distance passenger traffic once carried on U.S. railways. However, there remains a basic network of express trains with sleeping, restaurant, and entertainment cars. These are operated by *Amtrak.* Amtrak is an independent semipublic corporation, set up by the U.S. government in 1970 to run intercity passenger trains at a time when U.S. railways were facing serious financial losses. Handing passenger routes to Amtrak relieves private companies of the burden of maintaining unprofitable cross-country services. The fastest U.S. trains are the Metroliners, running between New York and Washington, which average about 125 kph. Three-fourths of U.S. rail users travel on local commuter trains.

In Canada, the situation is similar to the United States. The fastest trains operate services between Toronto, Ottawa, and Montreal. Most passenger travel is in the densely populated eastern part of the country, but the railways mostly carry freight. New lines have been opened to haul bulk minerals and timber, while long-distance trans-continental lines have suffered serious withdrawals of passenger services.

Central and South America. In Central America only Mexico has a network of railways. In the smaller countries further south in Central America, lines are usually isolated in coastal regions. Panama had a railway

crossing the narrow isthmus by 1855, long before the Panama Canal was built.

To travel inland from the west coast of South America involves crossing the Andes Mountains, and the railways of the region are spectacular. The railways built to carry the important mineral resources in Peru and Bolivia rise to almost 6,000 metres above sea level, the highest in the world. They accomplish this feat by use of steep gradients, zig-zags, sharp curves, tunnels, and rack sections. Argentina has more than 40,000 kilometres of railway lines, on three gauges. They radiate from Buenos Aires in the east, with connections to the steam-operated railway of Paraguay, as well as to the system in Uruguay. Brazil has nearly 37,000 kilometres of railway lines. Ninety per cent of Brazil's railways are less than 500 kilometres from the coast.

Australia. Australia's railways have more than 40,000 kilometres of track. Most of it is owned and operated by five government railway administrations. Four are state-run, the other is owned by the Australian federal government.

There are three different track gauges on the main railways of Australia. Only since 1970 has it been possible to journey by rail between Perth and Sydney on standard-gauge track. Passengers on the *Indian Pacific* train for this 3,938-kilometre trip enjoy the train's comforts for nearly 3 days, while it crosses the mostly barren landscape. Since 1917 this line has linked Western Australia's railways to the other Australian lines. In the middle of the Nullarbor Plain is the world's longest stretch of straight track, 478 kilometres. The *Trans Australian* train from Adelaide to Perth also uses this line. The railway staff and their families living along the track are so isolated that the *Tea and Sugar* train visits every week, with on-board medical and supermarket facilities, and a cinema.

The *Ghan* train is named after the Afghan camel drivers who once drove teams of camels in northern South Australia. This train has an entertainment car, and links Adelaide to Alice Springs, a journey of 1,544 kilometres. Like other Australian trains, it carries cars and loaded trucks.

All the state capitals except Darwin are now on the 4 ft. $8\frac{1}{2}$ in. (1.435 metre) gauge, but between Adelaide and Melbourne the gauge is 1.600 metre, and the *Overland* night train is the only through service between these two cities. From Sydney, day and night trains go to Melbourne and Brisbane. Others go to Canberra, and use the electrified line over the Blue Mountains.

The biggest state railway system is Queensland's, with a 1,681-kilometre line north to Cairns, and several long lines inland. Queensland also has an extensive system of 2 ft. (0.610 metre) gauge lines in its sugar plantations. Freight trains carry agricultural traffic in Queensland, and coal in New South Wales.

New Zealand. All New Zealand's railways were built on the 3 ft. 6 in. (1.067 metre) gauge to keep costs low. The terrain is rugged and there are many impressive engineering feats such as tunnels and viaducts, especially in the earthquake-prone North Island. Here, the main trunk line traverses the famous Raurimu spiral. In a series of loops over 11 kilometres, the railway climbs a steep gradient of 1 in 52. In the northeast of North Island, some specially-built lines carry timber from man-made forests.

Passenger services make up only 5 per cent of the railways' income. Six main trains run on each of the islands on most days. The 12-hour overnight journey between Wellington and Auckland (685 kilometres) is provided by the *Northerner*. A 10-hour daytime service is run by the *Silver Fern* railcar train with buffet service. The branch to Napier in the east is served by the *Bay Express,* another first class train, with an observation car; on this branch is the 97-metre Mohaka viaduct, the highest in the country.

North and South Islands are linked by ferries which carry both road and rail vehicles. The two island's rail systems developed separately, but always used common rolling stock. The ferry link was completed in 1962. There is a rail connection of 351 kilometres to Christchurch. From there the only line to the west coast climbs to Arthur's Pass where the steeply graded 13-kilometre stretch through the Otira tunnel is worked by electric locomotives. The *Southerner* covers the 594-kilometre distance along the east coast from Christchurch to Invercargill in 9 hours. In 1955, a 9-kilometre tunnel was built to by-pass the famous Rimutaka incline. As many as five steam locomotives were needed to pull trains up 265 metres over a 5-kilometre stretch.

China. The railways of China are efficient and are expanding faster than any other system. Railways are the major carrier of people and of freight, such as coal, pig-iron, and grain. Freight trains of several thousand metric tons are hauled by pairs of mechanically-stoked steam locomotives. Locomotives and passenger coaches are similar in design to those of the former Soviet Union, since the Soviets helped the Chinese to set up railway workshops in the years following the creation of the Communist People's Republic in 1949. The Chinese are unique in still building steam locomotives. They need all the motive power they can get to keep pace with demand, and steam traction still makes sense in a country which is rich in coal but without much oil, and which is trying to be self-sufficient.

There are vast areas of China without railways. The existing rail system is nearly all in the east of the country. One main line stretches 2,313 kilometres northward from Guangzhou (Canton) to the capital, Beijing (Peking), and continues to the northeastern industrial area around Shenyang and on to Manchuria. A second main line extends from Beijing southeastward to Shanghai (1,462 kilometres), and links with the Guangzhou route further southwest. These main lines are not hilly routes, but the lines heading westward from the junctions on the main north-south line have to cross high mountains. New railways across these natural barriers have been built to open up remote areas of the country, and to reach mineral deposits. One line has 405 tunnels in 916 kilometres, another has 427 tunnels in 1,065 kilometres. Lines that are being developed in the 1990's include the long-distance line to Urumqi in the far northwest. This line is being rapidly electrified, so that it could in future join up with railways in Kazakhstan, shortening by about 1,000 kilometres the rail link from China to Europe. At

the beginning of this long line, at Lanzhou, a second line branches westward before turning south. This branch is being extended south to Lhasa in Tibet.

Europe. Each country in Europe has its own railway system with a distinctive character. This section describes some major networks. For railways in the United Kingdom, see under *United Kingdom* below. European railways operate their trains—diesel or electric, multiple units, or locomotive hauled—according to the geography, and the needs of local people. Most use the standard 4 ft. 8½ in. (1.435 metre) gauge. Exceptions are Finland and Russia, 5 ft. (1.52 metre), and Spain and Portugal, 5 ft. 6 in. (1.676 metre). European national railways cooperate to run a network of international trains, often made up of carriages from more than one country, and sometimes including sleeping cars and wagons carrying passengers' cars. Ferries link rail systems across water. The shortest connection to Scandinavia is by train ferry from Denmark to Sweden. Trains can pass on to non-standard gauges so long as wagon wheels are adjustable, or the bogies can be exchanged. There are a number of different electrification systems in Europe. Some locomotives can switch from one system to another without stopping. This makes it possible to maintain fast schedules on express trains which often provide high-class passenger service, including restaurants and business facilities. This enables travellers to journey distances of several hundred kilometres, yet return home the same day.

Several European countries operate high-speed passenger services. Italy's *Pendolino* trains, which tilt to take curves at high speeds, are used on the Milan to Rome route. Germany runs high-speed trains from Hamburg, via Stuttgart, to Munich, with trains reaching speeds of up to 250 kph. Europe's fastest train is France's TGV express. The new track for the high-speed trains between Paris and Lyon was finished in 1983, and another stretch was completed in 1989 serving western France. A TGV service will operate to the Channel Tunnel, with a link between Paris and Lille, and there are plans to extend the high-speed rail network to Belgium, the Netherlands, and Germany.

The reunification of Germany in 1990 led to greatly increased traffic between the former West Germany and East Germany, and the reconnection of routes that for over 40 years had been disrupted by the frontier dividing West from East. Berlin, Dresden, and Leipzig are now integrated into the German intercity network. The Hamburg to Berlin line was scheduled to be electrified, as were railways from Austria to the Czech Republic and Slovakia. Freight traffic across Europe is an important international operation. Special arrangements facilitate the interchange of wagons between countries and maintain uniformity in operating standards.

India. More than 10 million people travelling in 11,000 trains use Indian railways every day. Some routes are so congested that passengers ride on the roofs of carriages. It is the world's fourth largest rail system, with a route length of more than 60,000 kilometres. Most of the track is broad gauge 5 ft. 6 in. (1.676 metre), and the proportion of broad gauge is increasing as new lines are built and smaller metre gauge lines are converted on busy routes.

The basic broad gauge rail network was planned in the 1850's, and then included what is now Pakistan railways. The lines from Delhi to Bombay and Calcutta are electrified. These main routes carry most of India's huge freight traffic: cement, coal, fertilizers, food grains, petroleum, and steel. The railways are one of India's greatest assets, with many signs of British influence and design still apparent. The official language on the railways is still English, but since independence in 1947, locomotives (first steam, then diesel and electric) and rolling stock have been built in India. Efficient research establishments maintain a modernization programme.

Many steam locomotives are in use, mainly on the metre gauge track. Steam locos on the broad gauge track haul the slowest passenger trains. Diesels haul freight when possible. The passenger network is highly organized, and covers the whole country. The service is

Double decker trains are used in Italy, *left,* and other European countries to relieve overcrowding on busy commuter lines.

Indian railways carry more than 10 million people every day. Stations provide refreshments and pre-booked meals during the train's long halt.

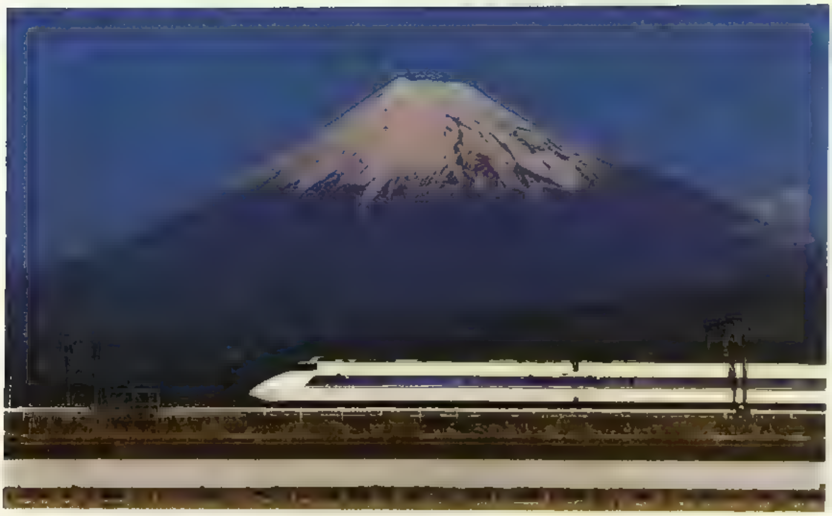
used to capacity by the public, and there is a detailed reservation system now largely computerized. Journeys are slow by modern standards, with lengthy halts at stations for refreshments or for pre-booked meals to be brought aboard. Many trains are impressively long, up to 18 heavy coaches. They usually have at least one air-conditioned car. In every coach, daytime seats can be converted into sleeping berths. Even the best trains, such as the all air-conditioned *Rajdhani Expresses* from New Delhi to Bombay and Calcutta, average no more than 85 kph. India's fastest train, the *Shatabdi Express* from Delhi to Bhopal, averages 90 kph for the 600-kilometre journey. A more usual average speed for a good train is 50 to 60 kph. On the metre gauge, trains are slower—50 kph on one of the best, the *Pink City Express* to Jaipur. The suburban electric trains in Bombay and Calcutta are the most overcrowded. The doors are never closed, people hang on the outside, and a single train may well carry twice its 1,500 official total of passengers. Calcutta has the first stage of a metropolitan underground railway, and Madras has a long-established metre gauge electric suburban system.

There are also other narrow gauge systems throughout India, some on 2 ft. 6 in. (0.762 metre) gauge, like the Baroda State Railway, and others 2 ft. gauge (0.610 metre), such as that at Gwalior. There are several interesting lines serving hill stations. For example, Simla (also spelled Shimla) in the foothills of the Himalaya, can be reached by a vintage railcar, which makes the winding 96-kilometre climb in 4 hours, with a stop for breakfast half-way. The so-called *toy train* (0.610 metre gauge) to Darjeeling is a delight for the traveller not in a hurry. Its old steam engines, whistles blowing, cross back and forth over the road in competition with the local bus service. It takes more than 8 hours for the 87-kilometre ride including 4 spirals and 5 zig-zags to gain height. The line to Ootacamund in the south is a metre gauge service by steam engines pushing trains up rack sections along ledges and over viaducts. Indian railways have unrivalled variety and tourists can sample a taste of former luxury on the *Palace on Wheels,* a tourist train made up of saloon cars that once belonged to various maharajahs. Delhi has a well laid out railway museum, with open-air exhibits.

Japan. The Japanese make more rail journeys per head of population than any other nation, on 26,000 trains a day. There is an extensive 3 ft. 6 in. (1.067 metre) railway network, mostly electrified. To meet the demands of the densely populated industrial region along the south of the largest island Honshu, the fast "Bullet" trains started running in 1964 between Tokyo and Osaka, on a completely new 4 ft. 8½ in. (1.435 metre) gauge railway *(Shinkansen)* over long viaducts and through 66 tunnels (12 more than 2 kilometres long).

Shinkansen trains are usually 16-car electric sets and can maintain very high speeds. On the later extension of the track from Osaka via Hiroshima to Fukuoka/Hakata on the southern island of Kyushu, half of the 554-kilometre-long track is in tunnels. These fast lines take only passenger trains. They are free for maintenance from midnight to 6 a.m., when the first train of the day leaves Tokyo for Fukuoka. The trains are very smooth running, and noiseless. There are *green cars* (lounges) in every train, and restaurant cars in the faster ones. The drivers receive signalling instructions on an instrument in their cab, and the line is continuously monitored for earth tremors. There are also *Shinkansen* lines from Tokyo to Niigata on the west coast (301 kilometres) and to Morioka in the north (497 kilometres) from where ordinary trains proceed to the northern island of Hokkaido through the Seikan tunnel, which at 54 kilometres is the world's longest rail tunnel. The 1.067-metre gauge system carries all freight traffic, as well as sleeping car trains and other passenger trains replaced on main routes by the high speed services.

South Africa. The South African railway system (Spoornet) is predominantly a freight-carrying business with few passenger trains, although freight trains usually have brake-van passenger compartments. There is at least one passenger train a day, with good facilities, on



The Japanese "Bullet" train can travel at an average speed of more than 160 kilometres per hour. The trains are very smooth running, and noiseless inside.

each of the main electrified lines from Johannesburg to the coastal cities of Durban, East London, Port Elizabeth, and Cape Town. Speeds are not high. The *Blue Train* which leaves Pretoria up to three times a week to make the 25-hour, 1,600-kilometre journey to Cape Town is known as the world's most luxurious train, with a standard of service and facilities matching those in a first-class hotel. Although trains operate on the 3 ft. 6 in. (1.065 metre) gauge, the clearances enable the coaches to be only slightly narrower than those used on broad-gauge on European railways. This is evident in the massive size of South African steam locomotives. About 200 remain in stock, now mostly used on special runs on ordinary service trains for the pleasure of railway enthusiasts. There are a few steam trains in normal everyday use on coal mine lines. The 3 ft. (0.610 metre) gauge lines south of Durban are used by a private company which runs a freight service for timber and agricultural traffic. The narrow-gauge line from Port Elizabeth is used for limestone and apple traffic; this line has the Van Staadens viaduct, 197 metres long and 78 metres high.

Examples of modern conveyor-belt type rail operations are the 830-kilometre railway from Sishen in northern Cape Province to Saldanha Bay north of Cape Town. This electric line operates on the unusually high 50 kV A.C. It transports iron ore. Another modern freight line runs from the coalfields at Vryheid, to take 5,500-metric ton trains to the purpose-built harbour at Richards Bay, north of Durban. There are rail connections with passenger services from South Africa to Namibia and to Zimbabwe through Botswana, but the line to Mozambique carries passengers no further than the border.

United Kingdom. The railways of the United Kingdom (UK) are largely focused on London, with the main lines radiating from the original seven major terminus stations in the centre of the city. British Rail operates the system, and carries more than 2 million passengers a day on about 15,000 trains over its 18,500 kilometres of lines.

There are two main trunk routes. The electrified westerly line runs northward from Euston station, London to Glasgow, with branches to Birmingham, Manchester, and Liverpool. A more recently electrified easterly line from King's Cross, London, goes by way of York and Newcastle to Edinburgh. This route now takes the UK's fastest trains which travel at an average speed of 160 kph, with maximum speeds up to 225 kph. Most of the intercity services on non-electrified routes are provided by *Inter City 125* high-speed trains with a power car at each end. These trains were introduced on the London to Bristol and South Wales route in 1976, and travel at up to 200 kph. Other UK trains are locomotive-hauled, and include sleeping car and car-carrying services. Diesel-electric trains called *Sprinters* are used on cross-country routes, especially in Wales and the north and west of Scotland where railcars are economic for working on long, but lightly-used, single lines with modern radio signalling.

London is well served by suburban lines. Two of these lines from north of the city use the 25 kV overhead electric system and go on to serve stations on the underground railway system. One line continues to a junction with the Network Southeast lines south of the River Thames. These lines are electrified at 750 volts from a third rail, thus needing special dual voltage trains. London will also handle rail traffic from the Channel Tunnel, due to open by 2000. The southeast electrified lines into London provide the world's busiest suburban services, with maximum use in the morning and evening peak periods. The rail area within a radius of about 120 kilometres of London is managed as one sector, and receives substantial government subsidy because of its essential but uneconomic services to the capital.

Freight on British Rail is made up of container traffic, and bulk materials such as cement, coal, and stone. Some trains are run to a regular schedule for individual companies. In the summer months steam locomotives hired by private rail preservation groups haul trains for day trips in scenic areas. Day trips on trains with dining facilities are also popular and profitable.

Ireland. The railways of the island of Ireland are all on the broad 5 ft. 3 in. (1.600 metre) gauge. The Republic has 1,950 kilometres of railway. The state transport systems, *Córas Iompair Éireann* (CIE) owns the railways. A CIE subsidiary, *Iarnród Éireann,* runs the network. Iarnród Éireann operates an up-to-date system, and provides passenger services on the main lines from Dublin to the south and west of the Irish Republic, with little interconnection of the routes. Freight trains have access to additional lines, and carry mainly cement, fertilizers, and sugar beet. There is an important container business trade to the seaports and to Belfast, in Northern Ireland, for ferries to the UK mainland. The passenger service on the main line between Dublin and Belfast is shared with Northern Ireland Railways. The Northern Ireland Railways Company operates about 300 kilometre of lines.

Dublin has a rapid transit railway, DART (Dublin Area Rapid Transit), that was completed in 1984. A 36-kilometre stretch of existing lines from Howth in the north to Dun Laoghaire and Bray in the south was electrified, and some new stations were opened.

Railway enthusiasts

People remain fascinated by the steam railway locomotive, often described as the machine most closely resembling a living creature. This fascination is responsible for the growing interest in railways as a leisure pursuit, and for the many books, magazines, and videotapes on railways. Many countries have railway museums. On preserved lines, steam enthusiasts can enjoy the sight, sound, and smell of a working steam locomotive, ride on trains, or even run then. Railway preservation schemes have grown up, notably in America, Australia, Britain and some other European countries. Volunteers restore disused locomotives and carriages, and operate them on a short piece of track, or an abandoned branch line, or on main-line railways. The Talyllyn Railway in Wales in 1949 and the Puffing Billy Railway in Australia in 1953 were two of the first.

There are more than 1,000 preserved steam locomotives in Britain and 2,000 in America. Narrow-gauge trains cost least to run but, especially in Britain, there are also standard gauge (1.435 metre) preserved lines. The Bluebell Railway in Sussex was the first standard gauge preserved line in 1960. The Nene Valley Railway in Cambridgeshire, England, specializes in overseas railways, and has locomotives and carriages from a number of European countries.

People who want to enjoy the sight of steam locomotives in regular everyday use can travel to India or China, where steam trains still operate.

History

The first railways were made by laying down strips of timber inside and near mines along which the wheels of carts could run more easily. Such rail-roads were built as early as the 1550's in Europe. By the early 1700's, wooden wagonways were common in coal mines in the north of England. Their use enabled horses to pull heavier loads. From 1738, cast-iron plates were nailed to the wooden rail to prevent wear.

In time, wheel design was adapted so the wheel ran on the upturned edge of the plate. In 1786 William Jessop, a British railway pioneer, laid the first true railway, at Loughborough in Leicestershire. It was made of short cast-iron rails supported at their ends on stone blocks; the wagon wheels had a *flange,* or projecting rim. Jessop was responsible for building the Surrey Iron Railway, the world's first public goods railway, which opened from Croydon to Wandsworth, London, in 1803. It was worked by horses which could pull trains weighing 55-metric tons. Traces of this railway can still be found in Surrey, but it never reached more than part of the way to its intended end at Portsmouth, in Hampshire.

The railway age begins. Britain led the way in pioneering steam locomotives for use on railways. Richard Trevithick, a Cornish mining engineer, built the first steam engine that could use high-pressure steam. He converted it into a locomotive which in 1804 was able easily to pull 25-metric ton loads on the plateway of an ironworks at Merthyr Tydfil in south Wales. The first horse-powered public passenger tramway in the world was opened in 1807 between Swansea and Mumbles in Wales.

The world's first public railway to use a steam locomotive was the Stockton and Darlington Railway in northeast England, opened in 1825. At the line's official opening, the brilliant engineer George Stephenson drove his *Locomotion* at 24 kph, pulling a train mostly of wagons carrying people. In 1829, he and his son Robert won a competition with their steam locomotive, *Rocket,* which drew a train of 20 metric tons 56 kilometres in under 2 hours, reaching a speed of 38 kph. This engine was chosen to haul a special train when the Duke of Wellington opened the Liverpool and Manchester Railway in 1830. This event marks the beginning of the railway age. The line was completely steam-worked and ran regular scheduled services for passengers. The Stockton and Darlington line reverted to using horses for passenger trains after its opening, and used steam locomotives for coal trains.

About the same time in the United States, the Baltimore and Ohio Railroad was the first in North America to use steam. Its locomotive *Tom Thumb* later broke down in a race against a horse, so it was the South Carolina Railroad that started the first regular U.S. steam services, with its locomotive *Best Friend of Charleston* in 1831.

Initial doubts about the reliability of steam locomotives were swept away by the success of the Stephensons' engines, which were soon in demand in other countries. Britain's first trunk railway was the Grand Junction, built by Joseph Locke, one of George Stephenson's pupils. It linked Birmingham with the Liverpool and Manchester Railway at Warrington in 1837. The rail link to London was completed with the London to Birmingham Railway built by Robert Stephenson in 1838. Locke was also the engineer of the London and Southampton Railway. The building of the railways required large numbers of workers, usually equipped only with picks and shovels. One of the most famous contractors who employed railway workers was Thomas Brassey who worked on the Grand Junction Railway. The

Historic trains include a steam locomotive operated by railway enthusiasts over the Zig Zag railways in Australia.

workers were known as *navvies* (from the canal builders of the 1700's, who were called *navigators*). Brassey and his navvies built more than 10,000 kilometres of railways around the world. Their achievements included the Paris-Rouen line in France, the Canadian Grand Trunk line, and other lines in Australia, India, and Argentina.

London's first local railway was opened from London Bridge to Deptford in 1836. Ireland's first railway was the 10 kilometre line from Dublin to Kingstown Bay (now Dun Laoghaire) in 1834. Until 1854 this was operated in part as an *atmospheric railway.* The train was connected to a piston that moved along a continuous tube laid between the tracks from which air was pumped by stationary engines. The South Devon Railway was also built on this principle by Isambard Kingdom Brunel, but it was not a success.

Brunel was the engineer of the Great Western Railway which was built from London to Bristol in 1841. He chose a broad gauge of 7 ft. (2.140 metres) instead of the 4 ft. 8½ in. (1.435 metre) used by the other railways. A British government commission decided in favour of the narrower gauge, but it was 1892 before the Great Western had changed all their track. Until then this railway ran a mixed gauge system with a third rail laid to allow other companies' trains onto their tracks.

The 1830's and 1840's were the years of so-called *railway mania.* Railway companies put forward many schemes to build sections of railway. The government examined them, and discarded most. Reckless investors lost money, although some, like the "railway king" George Hudson, became rich. Hudson arranged mergers of small lines, and ended up controlling most of the railways in northeast England. Through a process of line-linkage, London was linked to Scotland in 1850. By that year there were more than 9,600 kilometres of railways in the United Kingdom. All the railways were run by private companies.

Developments in other countries. Most European railways bought their first locomotives from the Stephensons in Britain. The Stephensons also supplied Canada's first line in Quebec province in 1836. France's first railway opened in 1832, Belgium's in 1832, and Germany's in 1835. These railways were soon under state control and there were similar railways in Russia, Italy, Switzerland, and Denmark in the 1840's; Sweden, Norway, and Portugal in the 1850's; Turkey and Greece in the 1860's.

Rail progress was also rapid in the United States. By 1835, the United States had more than 1,600 kilometres of railroad. Since so much of the interior was wilderness, the U.S. government offered large grants of money and land to encourage the building of railways. This was accelerated when it was seen how helpful railways were to the North in its fight against the Southern States during the U.S. Civil War (1861-1865). In 1862 President Abraham Lincoln appointed the Central Pacific to build a railway east from Sacramento, California, and the Union Pacific to build a railway west from Omaha, Nebraska. The Central Pacific was built by thousands of Chinese labourers. Its tracks had to cross the Sierra Nevada mountains. The workers from the east were mostly Irish immigrants. They had to build across the Rocky Mountains and risk attacks from Indians. The two lines met in the mountains of Utah in May 1869. The first transcontinental line was complete. The United States had four more transcontinental lines by the end of the 1800's. In 1885, the Canadian Pacific line was complete from Montreal to Vancouver. Locomotives had improved greatly in power, and could travel at between 80 and 100 kph.

Comfort and safety. George Mortimer Pullman, an American inventor and businessman, had built his first sleeping cars and dining cars by 1865. Coaches were now bigger and, in the United States, took on what became a familiar design, with open viewing balconies at the ends. Britain's first sleeping car was used on Scottish routes in 1873. Railway accidents were common in the early years, but safety improved in the mid-1800's. The electric telegraph speeded up communications. George Westinghouse, an American inventor, invented an air brake in 1872. In 1889, the worst accident to date in the United Kingdom occurred near Armagh on the Ulster Railway. Seventy-eight people, many of them children, were killed. This accident spurred the government to rush through laws to compel all railways to use the block signalling system, and to have continuous brakes through trains. These systems would have prevented the Ulster accident.

Railways in developing countries. European countries built railways in their overseas colonies. Spain built a railway in Cuba in 1837. The Dutch built railways in Java. France and Germany built lines in parts of Africa and Southeast Asia.

British Guiana was the first British colony with a railway, in 1847. Britain's biggest efforts in railway construction were in India in the mid-1850's. Lord Dalhousie, then governor general, was responsible for enforcing a single gauge, 5 ft. 6 in. (1.676 metre) for a network to link up the seaports of Bombay, Calcutta, and Madras. The railway also gave swift access to the North West Frontier for military purposes. Later, small feeder lines were built to reach isolated villages and provide help in famines. These lines were built on the narrower metre gauge to save money. As a result India had two gauges.

South African railways started at Cape Town. Inland development was slow and not until the late 1800's were lines constructed inland over the mountains. This new phase arose when first diamonds and then gold were discovered. Cecil Rhodes encouraged the building of the railway as far as Johannesburg, reached in 1892. The Portuguese built a second line from the eastern coast of Africa.

In Australia, gauge problems hindered progress ever since the first railways were built in the mid-1850's. Poor communications and the unwillingness of the states to agree on a standard system resulted in three different gauges being adopted. An attempt was made to set a standard in 1917, by completing the Transcontinental Railway from Kalgoorlie to Port Augusta on 4 ft. 8½ in. (1.435 metre) gauge. At 1,680 kilometres, this railway extended for most of the transcontinental route, but it was not completed until 1970. New Zealand's gauge was settled as 3 ft. 6 in. (1.067 metre) but its first railway was built at Nelson on 3 ft. gauge in 1862. Britain was influential in Argentina, where 5 ft. 6 in. gauge was used in 1857, and also in Japan which adopted 3 ft. 6 in. gauge.

Engineering improvements. Railways opened up many parts of the world to development and trade. By 1870 most of Europe's major rail system had been built. Some of these lines require that tunnels be blasted through the Alps to connect France, Switzerland, and Italy. In 1891 Russia began work on the Trans-Siberian railway, which was completed in 1916. At 9,010 kilometres it is the world's largest continuous railway.

After the mid-1800's railways started to use steel for rails and wagons. Steel passenger cars replaced wooden cars, and all-steel freight cars appeared as early as 1896. The railway engineers were responsible for many of the great engineering feats of the 1800's and early 1900's. They built Robert Stephenson's tubular bridge across the Menai Strait on the Chester and Holyhead Railway in Wales (1850), the Forth Bridge in Scotland (1890), and Sydney Harbour Bridge in Australia (1932).

The world had more than 200,000 kilometres of railways by 1870. A Belgian engineer, Georges Nagelmackers, founded the Wagons-Lits Company which provided luxury sleeping and dining cars on international trains such as the *Orient Express* (1883) and the Paris-St. Petersburg express (1895).

Electric trains. The first trials with electric trains were made by the German inventor, Wernher von Siemens in Germany in 1879. An electric railway was opened in England on Brighton seafront in 1883. After 1900, many European railways started electrifying their main lines. Italy and Switzerland were among the first to do so; these countries could use hydroelectric power for cheap electricity. Electricity from water power was first used by Siemens for the Giant's Causeway tram service on the north coast of Ireland in 1883. The City and South London was the first underground electric railway in 1890, and the Liverpool Overhead Railway was the first electric elevated city railway in the world in 1893. In the early 1900's, main line suburban railways in the south of England began to change to electric traction. In Britain, the number of railway companies was rapidly reduced by amalgamations. By 1923, there were four large groups: the London and North Eastern; the London, Midland and Scottish; the Great Western; and the Southern.

Between 1914 and 1939, the railways in many countries, but especially in Europe and North America, started to lose business to motor vehicles, though most were still thriving. They responded with a new technical breakthrough—the use of diesel traction.

In 1932, Germany started the diesel-powered *Flying Hamburger*, a two-car train between Berlin and Hamburg which ran at an average speed of 124 kph. The U.S. Burlington *Zephyr* was a streamlined diesel train that in 1934 covered the 1,627 kilometres between Denver and Chicago at an average speed of 124 kph. However, the steam locomotives on the *Hiawatha* trains from Chicago on the Milwaukee line challenged the new technology with the fastest regular running times in the steam era. These trains reached 160 kph. In 1938, the British streamlined steam locomotive *Mallard* claimed the world speed record for steam at 203 kph.

Electric and diesel traction were nevertheless taking over rapidly. In the United States, the Santa Fe line opened the world's first regular scheduled diesel-electric freight service in 1940. After World War II (1939-1945) the railways were starved of investment. They faced serious competition from road transport and, on long-distance passenger routes, from airliners.

In 1948, the four British railway companies were na-

Drawing (about 1808) by an unknown artist

An early locomotive, built by Richard Trevithick of England, gave rides to curious Londoners in 1808. Trevithick also built the first successful locomotive, which made its first run in 1804.

Important dates in railway development

1804 Richard Trevithick of England invented the steam locomotive.
1808 Richard Trevithick constructed a circular passenger railway in London.
1814 George Stephenson of England built his first steam locomotive; it carried 30 tons faster than did horses.
1825 The Stockton and Darlington Railway, built in England by George Stephenson, became the first railway to offer regularly scheduled steam-powered train service in the world.
1831 The South Carolina Canal and Railroad Company began the first regularly scheduled steam-powered train service in the United States.
1837 The Grand Junction, the first trunk railway, which linked Manchester with Birmingham and London, was opened.
1854 The first railway powered by steam linked Melbourne with the port of Sandridge, now Port Melbourne, in Australia.
1867 The American engineer George Westinghouse invented the pneumatic brake, making the operation of trains safer.
1869 The world's first transcontinental railway line was completed across the United States.
1870 The first major railway tunnel, the Mont Cenis Tunnel through the Alps was completed.
1872 George M. Pullman introduced the sleeper coach in railway travel.
1885 The first transcontinental railway link was completed across Canada.
1923 Most of the British railway companies were amalgamated into four large groups.
1938 The *Mallard*, a locomotive built in England, set the world speed record for steam locomotives at 203 kph.
1964 Japanese passenger trains began operating between Tokyo and Osaka at speeds of up to 209 kph.
1981 The *Train à Grande Vitesse* (TGV), ran from Paris to Lyon, at an average speed of 260 kph.
1989 South Africa ran the world's largest and heaviest freight train at 7.2 kilometres long, weighing 71,600 metric tons.
1994 The Channel Tunnel, linking the United Kingdom and France, was opened.
1995 The final stage of the 740-kilometre Konkan Railway was built near the western coast of India, linking Bombay to Mangalore.

tionalized to form British Railways. A modernization programme was begun in 1955. It involved the replacement of steam locomotives by diesels and, from 1963, the closure of many smaller lines. The steam era ended in most countries during the 1950's. The last steam locomotive built in Britain was *Evening Star* in 1960. The last steam locomotive was withdrawn by British Rail in 1968. Diesels replaced steam, while full-scale electrification schemes were being introduced. The French used electric traction particularly effectively at 25 kV rather than direct current, as was customary. From 1957, Trans-Europ Express trains competed for business with airlines, and were successful in providing high class daytime trains. In Britain, the overhead line electrification of the railway from London to Birmingham, Liverpool, and Manchester was completed in 1966 and later extended to Glasgow. In the 1970's, British Rail introduced trains with a top speed of 200 kph.

Railways today. In the 1990's, technology brought many innovations in rail travel. France's rail system continued to break speed records. Several countries, including Mexico and South Korea, expressed interest in buying French rail track technology. Rail services in several countries were privatized to encourage railways to be run as businesses, and not just as public services. In the United Kingdom, British Rail was broken into about 80 businesses in 1994 for transfer to private control. In the same year, similar changes were made to rail services in the Netherlands and Germany. Indonesian State Railways (Perumka) agreed to the introduction of private trains between Jakarta and Solo from 1995. New railways are being planned all over the world, including more high-speed links. Faster rail links may win back passengers on long-distance routes, particularly as the railway is increasingly regarded as more environmentally friendly than the car.

Related articles. See the *Transportation* section of the various country and continent articles. See also the following:

Biographies

Baldwin, Matthias William
Brunel (family)
Henry, John
Hudson, George
Jones, Casey
Pullman, George Mortimer
Stephenson (family)
Trevithick, Richard
Westinghouse, George

Other related articles

Air rights
Andes Mountains
Brake (Air brakes)
Diesel engine
Electric railway
Europe (pictures: Express trains; The Industrial Revolution)
Ghan
Industrial Revolution (picture)
Locomotive
Monorail
Rocket
Tom Thumb
Transportation
Trans-Siberian railway
Tunnel (Railway tunnels)
Underground

Outline

I. How railways serve the public
A. Passenger trains
B. Freight trains
II. What makes up a railway
A. Rolling stock
B. Tracks
C. Freight operations
III. Traffic control
A. Manual block signal systems
B. Automatic block signal systems
C. Other train controls
IV. Modernization schemes
V. Railways around the world
A. North America
B. Central and South America
C. Australia
D. New Zealand
E. China
F. Europe
G. India
H. Japan
I. South Africa
J. United Kingdom
K. Ireland
VI. Railway enthusiasts
VII. History

Questions

What is a *flange?* What does it do?
What event marked the beginning of the railway age?
What is a railway *gauge? Standard gauge?*
What is a sorting yard? A hump yard?
How are trains on the same track kept safely apart?
When was the first transcontinental railway line in the USA completed?
What is the world's longest railway line?
What is the speed of the world's fastest passenger train?
What is a *piggyback* service? A *shunting locomotive?*
What has hindered the progress of Australian railway construction?

Railway, Model, is a small railway that copies the appearance and operation of a full-sized railway. The hobby of building and operating model railways, is a favourite pastime for thousands of people.

A model railway can include all the major features of a real railway, such as locomotives, carriages, points, signals, stations, and bridges. Enthusiasts can also build realistic miniature towns and natural scenery as settings for the railway. Model railway carriages, freight wagons, engines, and other equipment can be purchased ready-made. But most model railway enthusiasts enjoy designing and assembling their own systems. They build models from kits, or they make them from parts and raw materials. Model railway builders lay down tracks according to their own layout designs, and they wire their railways to operate in a realistic way.

Model railways offer a variety of activities in addition to modelmaking, such as carpentry and wiring electrical circuits. Enthusiasts can concentrate on building only those parts of the system that they enjoy most, because the other parts can be purchased ready-made.

Model railway building differs from the hobby of operating toy trains. Model railways are made to represent real trains in accurate detail. In building their systems, model railway enthusiasts copy as closely as possible the appearance and operation of a real railway. Toy trains are larger than most model trains and they are built to withstand rougher handling. Toy trains do not have much of the fine detail and realism that model trains have. Toy train enthusiasts may put together large and highly complicated railway systems. However, most toy locomotives, carriages, and other equipment are purchased completely assembled.

Scale and size. Railway models are built to *scale.* The scale is the comparison between the size of the model and the full-sized railway, called the *prototype.* The most common model railway scales are called HO, OO, N, or O. In the *HO* scale each part of the model is 1:87 the size of the prototype. HO uses a *gauge* (track width) of 16.5 millimetres. This represents the standard track gauge of 1.44 metres on a real railway.

In the *N* scale, in which models are 1:160 the size of the prototype, models run on N gauge tracks that are 9 millimetres wide. Another popular scale is *OO* scale. OO models are 1:76 the size of the prototype. The gauge is 16.5 millimetres wide. Most toy trains are built in *O* scale, which is 1:43.5 the size of the prototype. They run on O gauge tracks that are 32 millimetres wide.

A layout built in N scale will take up less space than the same layout in HO scale. But a modelling enthusiast can build an N scale layout in a larger space and devote more of that space to scenery and buildings. A model railway may cover as little as 0.8 to 1 square metre. Many are built on tabletops made from a plywood sheet measuring 1.2 metres wide and 2.4 metres long. Bigger model railway systems can occupy most or all of a basement or attic.

Track can be purchased in short sections or in longer flexible strips. Sectional track comes in straight or curved pieces, which are put together to form the desired layout. Sectional model rail track resembles toy train track. But model railway track has more sleepers per section so it looks more realistic. Flexible track, often called *flextrack,* comes in strips one metre long. The strips can be put down either straight or curved to fit the layout design. Some modellers buy rails separately and spike them down by hand on individual wooden sleepers for greater realism.

Most model railways use the two rails to carry electrical current to and from the locomotive. The rails form

Operating model railways provides enjoyment for thousands of people. Enthusiasts assemble model railways from ready-made parts and from parts they build themselves. The trains are operated by electricity. Enthusiasts add to the pleasure of model railway building by creating realistic scenery.

Railway models are divided into two categories, *toy trains* and *model trains.* Each category is built to *scale,* which is the comparison between its size and the size of a real train. Most toy trains are built to *O* scale, *right.* The most popular model train scales are *HO, centre,* and *N, left.*

the sides of an electrical circuit, and the locomotive completes the circuit through its wheels and motor. Some model railways represent prototypes of electrically powered trains. Some of these models are powered through an overhead wire, as in a tram. Others receive power through an outside third rail, as in the elevated and underground trains operating in many cities.

Toy trains have a third rail running down the middle of the tracks. This rail and the side rails carry current to and from the toy train locomotive.

Locomotives for model railways are purchased already assembled or they are built from kits. Their power comes from household current that first passes through a separate electrical unit called a *power pack.* The power pack reduces the voltage of the household current to 12 volts. It also changes the type of current from *alternating current,* which continually reverses direction, to *direct current,* which flows in one direction. Both power packs and transformers include switches by which the operator controls the speed and direction of the locomotive.

Most model locomotives are made in one of two engine prototypes—steam or diesel.

Steam locomotives are especially popular with model railway enthusiasts, though they are rarely used on real railways. A great variety of steam locomotives were custom built for different railway companies. Each steam locomotive prototype has unique features that model builders value. Many enthusiasts enjoy building steam locomotives because the locomotives have many visible moving parts. In a steam locomotive model, the motor is usually located in the firebox behind the boiler. A set of gears connects the motor to the axles of the large drive wheels. Some steam enthusiasts, especially in the United Kingdom, build models that actually are steam-driven. These models are powered by liquid fuel or even coal that has been ground into small grains. The boiler, firebox, cylinders, pistons and piston rods are built to scale, and operate in the same way as the full size steam locomotives on which they have been modelled. Many model enthusiasts belong to clubs. Some of these clubs own terrains in which tracks are laid out permanently and where club members gather regularly to operate their model trains.

Diesel locomotives are simpler in appearance and easier to build than steam models. They are popular with enthusiasts who want to create a more modern looking system. Diesel locomotive models have a more standard appearance than steam locomotives, but they have a variety of paint and lettering designs that represent the different railway companies. Most diesel locomotive models have the motors in the middle of the body. The wheels are mounted on swivelling pieces called *bogies* attached to the bottom of the body. Gears connect the motor to the wheels of the locomotive. Many diesel models use two or more locomotive units to copy the makeup of real diesel locomotives. One of the model units might be a *dummy,* without motor or gears, which will still create the appearance of the real locomotive but at less expense.

Carriages for model railways usually come in kits that can be assembled with a few simple tools. Most are made of plastic pieces that snap together. More challenging kits, called *craftsman kits,* include a combination of materials, such as wood, metal, and plastic. The pieces of the model must be cut to size and fitted together. In many kits, the carriages are already painted. In others, the model builders paint the carriages them-

Lifelike scenery adds a feeling of variety and realism to a model railway layout. Enthusiasts can build an elaborate route that takes their trains through tunnels cut into a rugged mountain range, *left.* Model railway builders can also construct a highly detailed miniature town, *right.*

selves with their own designs. Some model builders combine parts from two or more kits.

Buildings and scenery. Much of the realism of a model railway depends on how creatively the builder designs the scenery of the system. The builder may send the train over a complicated route through tunnels and small towns, over rivers and roads, and into freight yards or passenger terminals.

There are a variety of kits for making buildings. Buildings can also be constructed from raw materials. Builders make most scenery by shaping wire netting or cardboard webbing into the contours of hills, valleys, streams, and other landforms. They cover this shell with plaster. Builders then apply paint and texture materials to represent earth and grass, and add miniature trees and shrubs to complete the landscape.

Other systems and equipment can be as simple or complex as the builder wishes. The basic wiring system for a model railway allows only one train to run at a time. More complicated wiring permits several trains to run at once. Signals reproduce the functions of their prototype systems and add additional realism. Sound effects systems recreate the sounds of steam and diesel locomotives. Some enthusiasts build working models of such equipment as drawbridges and coal hoppers. However, such accessories are more common in toy train systems. Advanced model railways may be operated by radio control or by computer.

Rain is a form of precipitation that consists of drops of water. Raindrops form when water droplets in clouds combine or when precipitation in the form of ice, such as snow, hail, or sleet, melts. Rain falls throughout most of the world. In the tropics, almost all the precipitation is rain. However, in the inland of Antarctica and in a few other places, all precipitation occurs as ice.

Raindrops vary greatly in size and in the speed of their fall. The diameter of most raindrops ranges from 0.50 to 6.40 millimetres. The larger the raindrop is, the faster it falls. At sea level, a large raindrop with a diameter of 5 millimetres falls at the rate of 9 metres per second. Drizzle, which consists of drops with a diameter of less than 0.50 millimetre, falls at the rate of 2.1 metres per second or slower.

The shape of a raindrop depends on its size. Raindrops with a diameter of less than 1 millimetre are round. Most larger raindrops become flatter as they fall.

Rain is necessary for life because it provides water for human beings and other animals and for plants. Few forms of life exist in places where little or no rain falls. In rural areas, rain helps prevent the loss of valuable topsoil by stopping dust storms. Rain also cleans the air by washing away dust and chemical pollutants.

Rain can be harmful as well. Too much rain may interrupt communications and cause flooding that destroys property and threatens life. Heavy rainfall also damages crops and speeds up the loss of soil.

Measuring rainfall

Rainfall is measured in various ways. The most commonly used instrument is the *rain gauge.* It is a cylinder

with a narrow tube inside and a funnel on top. Rain falls into the funnel and flows into the tube, where it is measured with a special "ruler."

A network of rain gauges is used to measure the annual precipitation of a region. In winter, or in the wet season, the gauges are placed about 15 kilometres apart. In summer, or in the dry season, they are set closer together because summer showers occur in narrow bands. The gauges are generally used on level ground. The total precipitation collected periodically throughout the year in all the gauges represents the annual precipitation.

Other instruments measure the *intensity of rainfall*—that is, the rate of rainfall within a certain period, usually an hour. A *weighing-type gauge* may be used. This instrument has a bucket into which the rain falls. The bucket stands on a platform attached by springs to a scale. The weight of the rain water pushes the platform down. The movements of the platform are recorded and stored in digital form and processed by a computer.

In some cases, *meteorologists* (scientists who study weather) measure rainfall with radar. This electronic instrument sends out radio waves that are reflected by raindrops. The reflected waves, called *echoes,* appear on a screen as spots of light. The brightness of the echoes depends chiefly on the size and number of raindrops. The echoes indicate the amount and intensity of rainfall. Radar measures scattered showers missed by rain gauges, which are too far apart to measure precipitation in all places.

Rainfall distribution

World distribution. The earth receives an average of about 86 centimetres of rain and other forms of precipitation annually. Some regions of the world have a much greater rainfall, and others get much less rain.

Some regions near the equator have received as much as 1,000 centimetres of rain a year. Rain usually falls every day of the year in such areas as western Africa and the Amazon River Basin of South America.

The coastal regions of the tropics also have heavy rains. The heaviest rainfall ever recorded for a 24-hour period occurred at Cilaos, which is on the tropical island of Reunion in the Indian Ocean. Cilaos received a total of 188 centimetres of rain on March 15-16, 1952.

Other regions of the tropics receive little rain. They include the vast deserts of Australia, northern Africa, and the Arabian Peninsula. The tropical desert of Chile had the longest recorded dry period. No measurable precipitation fell at Arica, Chile, in a 14-year period, from 1903 to 1917.

In the *temperate zones,* the regions between the tropics and the polar circles, cyclones bring heavy rains to the western coasts of some continents. However, deserts lie in the interior of these continents. Other regions of low precipitation occur around the polar circles.

In the United Kingdom, more than 200 centimetres of rain falls in the upland areas, while less than 76 centimetres falls in the eastern lowlands.

Australia receives less rainfall than any other continent except Antarctica. About half of Australia gets less than 25 centimetres a year, which is the normal minimum needed to avoid *aridity* (desert conditions). Over the whole continent, rainfall averages only 42 centimetres a year.

The driest part of Australia lies east of Lake Eyre, in South Australia. Here, rainfall averages only 10 centimetres a year, but is often much less. The driest part of New Zealand is in central Otago. Here, rainfall averages less than 30 centimetres a year. The wettest part of New Zealand is along the exposed western side of the Southern Alps, where annual rainfall often exceeds 700 centimetres. Tully, on the northeastern Queensland coast, receives an average of 440 centimetres a year—the highest in Australia. The highest recorded daily rainfall in Australia—91 centimetres—fell at Crowhamhurst, in Queensland, on Feb. 3, 1893.

Some rainfall records

The earth's average annual precipitation (including rain, snow, and hail) is about 86 centimetres.
Greatest rainfall in the world occurs at Mount Waialeale in Hawaii, in the United States. An average of about 1,168 centimetres of rain falls there yearly.
Least rainfall in the world is recorded at Arica, Chile, a desert town that receives an average of 0.76 millimetre a year.

What causes rain?

Formation of rain. Rain develops from water vapour in the atmosphere. This vapour forms when the heat of

World distribution of precipitation

the sun causes evaporation from the oceans and other bodies of water on the earth. The warm, moist air cools as it rises, and the amount of vapour it can hold decreases. The temperature at which air holds as much vapour as it can is called the *dew point.* When the temperature drops below the dew point, some of the vapour condenses into water droplets, forming clouds.

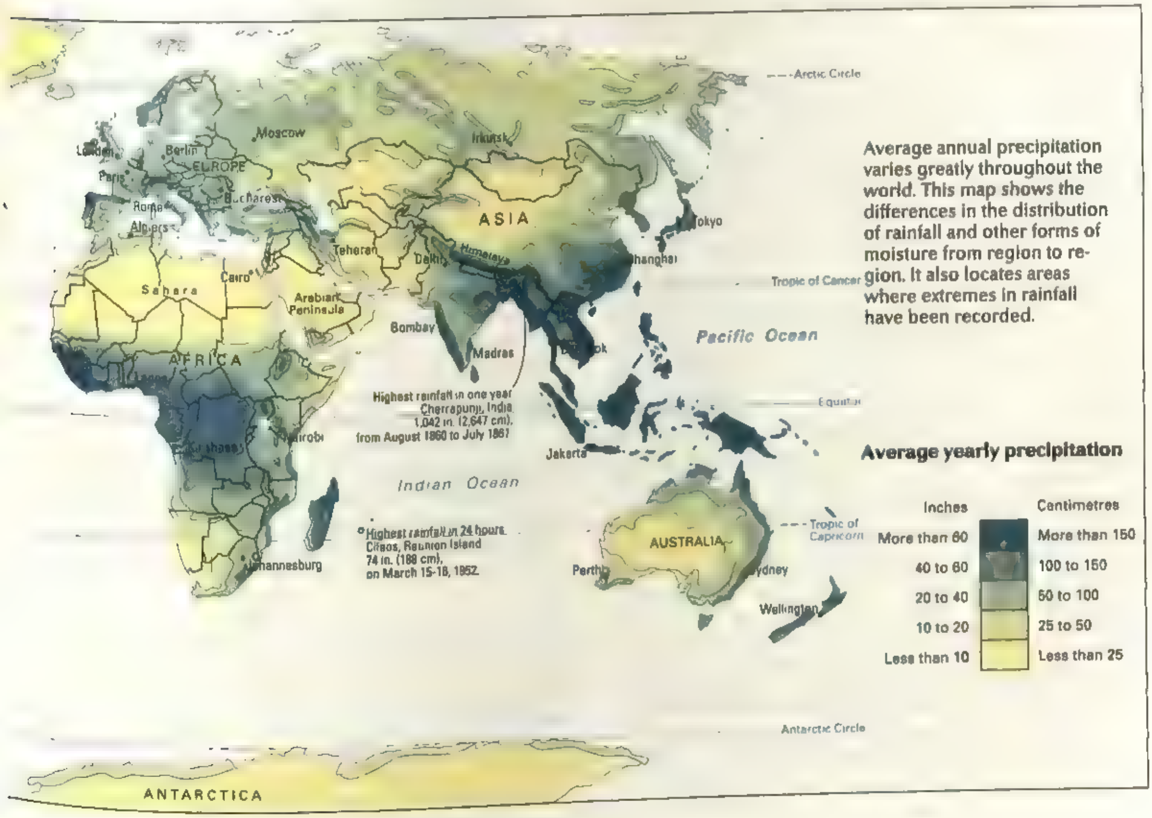
Water droplets form on tiny particles of matter known as *condensation nuclei.* Such nuclei consist of dust, salt from ocean spray, and chemicals given off chiefly by industrial plants and motor vehicles. As the water droplets form, heat is released, making the clouds warmer. The warmth helps the clouds rise, and they then become cooler. The formation of raindrops in such clouds is explained by the *coalescence theory* and the *ice-crystal theory.*

The coalescence theory applies to much of the rain that forms over the oceans and in the tropics. According to this theory, different sizes of droplets form in clouds. The larger droplets fall faster through a cloud than the smaller droplets do. As a larger droplet falls, it collides and combines with smaller droplets. This process is called *coalescence.* If a large droplet falls about 1.5 kilometres through a cloud, it may combine with a million smaller droplets. In this way, the droplets become too heavy for the air to support them. Some fall to the earth as raindrops. Others having a diameter of more than 6 millimetres tend to split into smaller drops. These drops will move upward if the cloud is rising rapidly. As they begin to grow, they again fall and repeat the coalescence process.

The ice-crystal theory accounts for much of the rainfall in the temperate zone. The process of rain formation based on this theory probably occurs more frequently than coalescence. The ice-crystal process occurs in clouds in which air temperature is lower than 0° C, the freezing point of water. In most cases, such clouds consist of droplets of *supercooled water.* Supercooled water is water that remains in a liquid state at temperatures below 0° C. In clouds of this type, ice crystals form on microscopic particles called *ice nuclei.* Most ice nuclei consist of extremely fine particles of soil or volcanic dust.

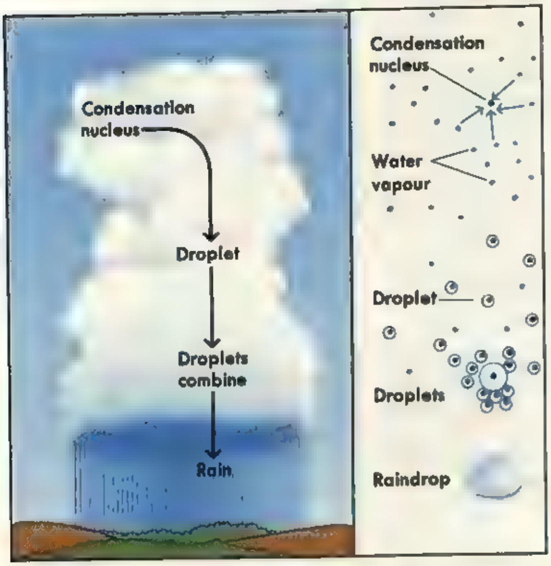
Ice crystals form when droplets of supercooled water freeze on ice nuclei. When the temperature drops to −40° C or below, the droplets freeze without ice nuclei. Under certain conditions, ice crystals may also form directly from water vapour. In such a case, water vapour is deposited on ice nuclei and freezes without first condensing into droplets.

Ice crystals that form near droplets of supercooled water increase in size when water vapour from cloud droplets is deposited on the crystals. As the crystals fall through a cloud, they may collide and combine with other crystals or with supercooled droplets. Crystals that become too heavy for the air to support fall out of the cloud. Such ice crystals become raindrops if they fall through enough air that is warmer than 0° C.

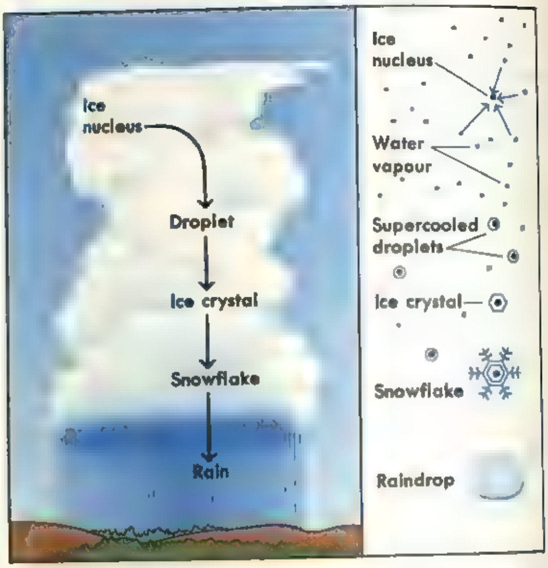


Average annual precipitation varies greatly throughout the world. This map shows the differences in the distribution of rainfall and other forms of moisture from region to region. It also locates areas where extremes in rainfall have been recorded.

How rain forms Weather experts have developed two theories of rain formation—the coalescence theory and the ice-crystal theory. The diagrams below illustrate the processes described by each of these theories.



The coalescence theory explains how water droplets form in clouds. A droplet forms when water vapour condenses on a particle called a *condensation nucleus.* As a droplet falls through a cloud, it combines with smaller ones. When it becomes too heavy for the air to support, it falls as a raindrop.



The ice-crystal theory applies to clouds of supercooled water droplets. Such a droplet, formed by condensing water vapour, freezes on a particle called an *ice nucleus.* The resulting ice crystal combines with others to form a snowflake. The snowflake becomes rain when it falls through air warmer than 0° C.

Experiments in *rainmaking,* also called *cloud seeding,* are based chiefly on the ice-crystal theory. In these experiments, various substances are put into clouds to serve as ice nuclei. This procedure sometimes helps produce rain and snow by promoting the formation of ice crystals. See **Rainmaking.**

Variations in rainfall. Rainfall is affected by a variety of factors such as latitude, large bodies of water, land features, air currents, and cities. These factors largely determine the variations in rainfall that occur throughout the world.

In general, rain falls more frequently in latitudes near the equator than in those close to the poles. At the equator, the intense heat of the sun causes large amounts of moisture to evaporate in the warm air. Because the polar regions receive little sunlight, the air there is too cold to hold much moisture. Areas near large bodies of water get more rain than areas in the dry interior of a continent. The larger amount of rainfall results from evaporation of moisture from nearby sources of water, including oceans, lakes, and irrigation systems. The lack of rain in the deserts of west central Asia is due mainly to their great distance from the sea.

Places on the windward slopes of mountains generally have more rain than areas at a lower elevation. The slopes help to produce rain by lifting warm, moist air to a higher altitude. There, the air cools, forming clouds and then rain. Most of the slopes away from the wind are dry because the wind carries little moisture across the tops of the mountains. In Asia the southern slopes of the Himalaya receive 510 to 1,500 centimetres of rain annually. But the northern slopes of the Himalaya average less than 25 centimetres of rain a year.

Seasonal rainfall, especially in regions near the tropics, is caused by winds that blow in an opposite direction in winter from in summer. Such winds are called *monsoons.* The monsoon that blows across southern Asia in the summer brings extremely heavy rains. The greatest amount of rain ever recorded in one year fell on the town of Cherrapunji, near Shillong, India. Cherrapunji received almost 2,647 centimetres of rain from August 1860 to July 1861.

Meteorologists believe cities promote rainfall, but they are not certain why. One possible explanation is that clouds may form more quickly in the heat generated by cars, heating systems, and sun-warmed concrete. Also, pollutants in the air over a city may act as condensation nuclei for raindrops.

Pollutants also cause *acid rain,* which forms when moisture reacts with nitrogen oxides and sulphur dioxide. These chemicals are released by motor vehicles, factories, and certain power plants. Such rain pollutes lakes and streams, endangering wildlife. It also damages crops, forests, and soil. See **Acid rain.**

Related articles. See the *Climate* section of the articles on the continents, countries, states, and provinces. See also:

Climate	Rain gauge
Cloud	Rainbow
Cloudburst	Rainmaking
Desert	Storm
Evaporation	Water
Humidity	Weather

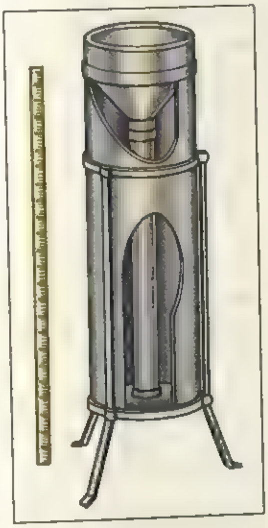
Rain dance is a ceremony performed by American Indians of the Southwestern United States to ask spirits to send rain for their crops. The Indians ask the spirits to send the rain in the proper amounts and at the right times. Indians hold most rain dances during the spring

planting season and in the summer while the crops are growing. Each tribe has its own particular ceremonies for bringing rain. For example, participants in the Papago Indian rain ceremony sing and dance and drink wine made from cactus juice. The Hopi dance with live rattlesnakes in their mouths to encourage the gods to send rain.

Rain forest. See Tropical rainforest.

Rain gauge is an instrument used to measure the amount of rain that falls in a certain place during a specific period of time.

One of the most common types of rain gauge is shaped like a cylinder and has a removable cover. Inside the cylinder is a long narrow tube, where the rainfall is measured. The top of the tube is connected with a funnel. The rain falls into the funnel and flows into the tube. The mouth of the funnel has an area 10 times that of the tube. This means that if 10 millimetres of rain falls into the funnel, it would fill 100 millimetres of the tube. The rain in the tube is measured by a "ruler." This ruler is scaled so that a depth of 100 millimetres gives a reading of 10 millimetres of rainfall.


Rain gauge

If the rainfall is so heavy that the water in the tube overflows, this extra rain flows into the space between the outside of the cylinder and the tube. After the rain in the tube is measured, it is poured out and the extra rain is placed in the tube and measured. The total rainfall equals the sum of these two measurements. A gauge is usually placed on the ground away from buildings and trees to ensure accuracy.

Some rain gauges can record the amount and the rate of rainfall. A *tipping bucket rain gauge* has a small bucket that tips and empties after it fills with rain. Each tip of the bucket activates an electrical switch that records the amount of rain. A *weighing rain gauge* collects water in a bucket that stands on a platform attached to a scale. As the bucket fills, the weight of the rain water pushes down the platform. This movement is recorded and processed by a computer.

Some rain gauges can be used to measure snowfall. But they do not provide very accurate measurements when used for this purpose.

Rain shadow areas occur where mountain ranges bar the path of moist onshore winds. As the winds rise to cross the mountains, rain falls on the coastal plains and mountain slopes. The dry winds then blow inland, but little rain falls beyond the mountain ranges. The dry area beyond the mountains is called a *rain shadow area.*

Northeastern Queensland in Australia has a rain shadow area west of the Great Dividing Range that receives less than 750 millimetres of rainfall a year. Another rain shadow area occurs in New South Wales, where the western slopes are sheltered from rain-bearing easterly winds. The Highlands of Scotland cause a rain shadow area to their east.

Rain tree, also called *monkeypod tree,* is a shade tree that grows in tropical climates. Rain trees have short, stout trunks and long spreading branches. Some trees measure more than 30 metres across. The trees are called rain trees because moisture that looks like rain often drips from them. However, scientists believe the liquid is really a discharge from insects feeding on the trees.

Rain trees have pink and white flowers. The seeds of the trees grow in thin, black pods that are often eaten by monkeys. A freshly cut tree has moist wood that can easily be carved, and it keeps its shape as it dries. Rain tree wood has a golden to dark brown colour and is used to make bowls, trays, and other articles.

The rain tree is native to Central America, South America, and the West Indies. In the United States, it is grown in Hawaii and Florida.

Scientific classification. The rain tree belongs to the family Leguminosae (Fabaceae). It is *Pithecellobium saman.*

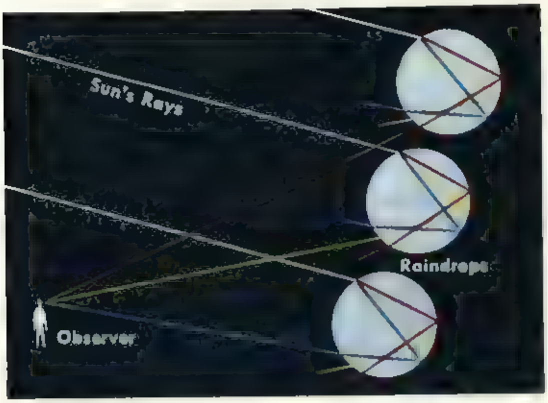
Rainbow is an arch of brilliant colours that appears in the sky when the sun shines during or shortly after a shower of rain. It forms in that part of the sky opposite the sun. If the rain has been heavy, the bow may spread all the way across the sky, and its two ends seem to rest on the earth.

The reflection, refraction, and diffraction of the sun's rays as they fall on drops of rain cause this interesting natural phenomenon. These processes produce all the


A rainbow appears in the sky when the sun shines after a shower of rain. After a heavy rain, a rainbow may form an arch of brilliant colours that spreads all the way across the sky. The two ends of the arch may appear to touch the earth.

How rainbows are formed

Raindrops act as tiny prisms and mirrors to break up sunlight into colours of the spectrum and send coloured light back to our eyes. Each drop forms many colours. But the colour that reaches our eyes from a particular drop depends on the angle between it and the line formed by the sun's rays. Many raindrops, each sending coloured light at certain angles, form a rainbow.



colours of the colour spectrum—violet, blue, green, yellow, orange, and red. However, the colours of a rainbow blend into each other so that an observer rarely sees more than four or five clearly. The width of each colour band varies, and depends chiefly on the size of the raindrops in which a rainbow forms. Narrow bands are caused by larger drops.

Sunlight is a combination of all colours. Different wavelengths of light exhibit different colours. You see the rainbow when the sun is behind you and the rain is in front of you. As a ray passes into a drop of rain, the water acts like a prism.

The ray is *refracted* (bent) as it enters the drop, and is *diffracted* (dispersed or separated) into different colours. As it strikes the inner surface of the drop, it is *reflected* (turned back). On leaving the drop, it is further refracted and dispersed. Many drops produce a rainbow. Each colour is formed by rays that reach the eye at a certain angle, and the angle for a particular colour never changes.

A complete bow generally shows two bands of colours. The inner and brighter one is called the *primary* bow. The primary bow exhibits red along the outer edge of the bow, and violet or blue on the inside. A less distinct *secondary* bow is sometimes visible outside the primary bow. The secondary bow is produced by sunlight passing into drops and undergoing a double reflection. Thus, the colour order is reversed from that of the primary bow—that is, red appears on the inside and violet or blue on the outside of the secondary bow.

A third bow, called a *tertiary* bow, is sometimes seen outside the secondary bow. It is produced from three internal reflections, and its colour order is the same as that of the primary bow. The colours of secondary and tertiary bows are increasingly less intense than those of the primary bow. In fact, they often appear as only bright bows of white light.

The higher the sun is, the lower the rainbow will be. If the sun is higher than 40 degrees, no bow will be seen. When the sun is near the horizon, an observer on a high mountain might see the entire circle of the rainbow.

Rainbows are often observed in the spray that flies from a garden hose or a waterfall.

See also **Colour** (The relation between colour and light); **Light** (How light behaves).

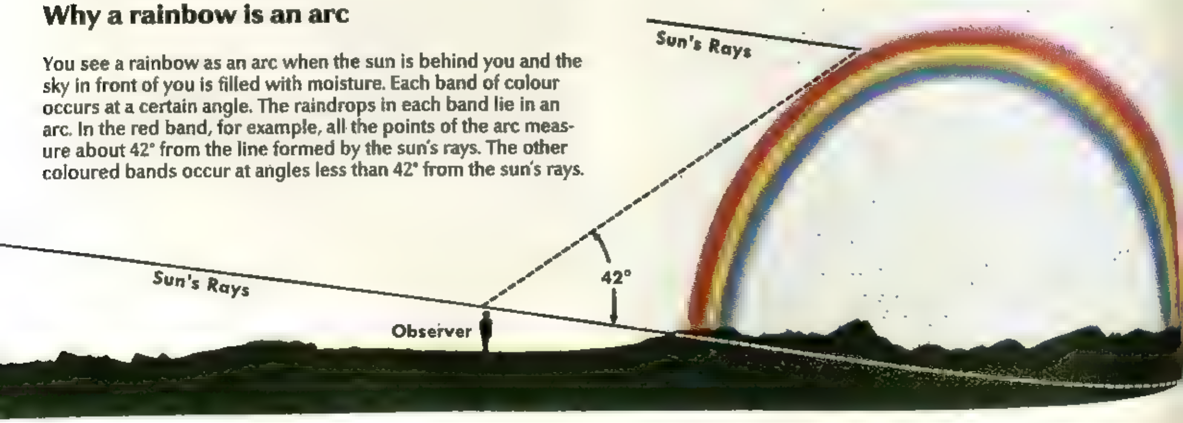
Rainbow Warrior was a vessel owned by Greenpeace, an international environmental organization, for use in antinuclear protest voyages. On July 10, 1985, two explosions tore open the hull of the vessel while it was berthed at Auckland, New Zealand. A photographer on board at the time of the explosion was killed. On July 23, a man and a woman, both French army officers, were arrested in New Zealand on charges relating to the explosion and sinking of the vessel. In 1986, the French government apologized and paid compensation. The two agents were then handed over to French military officials. See also **Greenpeace**.

Rainforest. See **Tropical rainforest.**

Rainier III (1923-   ) became prince of Monaco in 1949. His full name is Rainier Louis Henri Maxence Bertrand de Grimaldi. Rainier's marriage to American actress Grace Kelly in 1956 aroused international interest. The birth of their daughter Princess Caroline delighted Monaco. As long as the royal family continues, Monaco remains independent from France. The couple also had a son, Prince Albert, and a daughter, Princess Stephanie

Why a rainbow is an arc

You see a rainbow as an arc when the sun is behind you and the sky in front of you is filled with moisture. Each band of colour occurs at a certain angle. The raindrops in each band lie in an arc. In the red band, for example, all the points of the arc measure about 42° from the line formed by the sun's rays. The other coloured bands occur at angles less than 42° from the sun's rays.



Marie Elisabeth. Rainier's wife died in 1982 following a car accident near Monaco.

Rainier's grandfather, Louis II, was prince of Monaco before him. As prince, Rainier has provided low-cost housing, expanded schools, and tried to balance the budget of his government.

Rainier III

Rainier, Mount. See Mount Rainier.

Rainmaking, also called *cloud seeding,* is a process that makes rain fall from a cloud. People use the process chiefly to increase an area's general water supply, or its supply of water for irrigation, or for generation of electricity by hydroelectric plants. But they also use it to prevent heavy rainfall in areas where rain can damage crops. By seeding clouds before they reach such areas, experts can sometimes reduce the strength of a storm. Several United States scientists, working independently, developed rainmaking procedures during the 1940's.

Rainmaking methods. Rain occurs when the water vapour in a cloud forms ice crystals or water drops large and heavy enough to fall to the earth. In some cases, the chance of rain can be increased by adding substances called *seeding agents* to clouds. The seeding process works best in clouds from which rain is almost ready to fall. The substance used for seeding depends on the cloud's temperature.

At temperatures above 0° C, the chief seeding agent is a liquid composed of ammonium nitrate and urea. Particles of this substance cause water vapour to form raindrops around them. The seeding agent is sprayed from an aeroplane into the bottom of a cloud.

At temperatures below 0° C, clouds may contain *supercooled water.* This form of water may remain unfrozen in temperatures as low as −40° C. Supercooled water must form ice crystals in order to become heavy enough to fall to the earth. Ice crystals can be produced by using such seeding agents as dry ice or crystals of silver iodide. When the ice crystals form, they fall toward the earth as snowflakes. As the flakes enter a region that has a temperature higher than 0° C, they melt into rain.

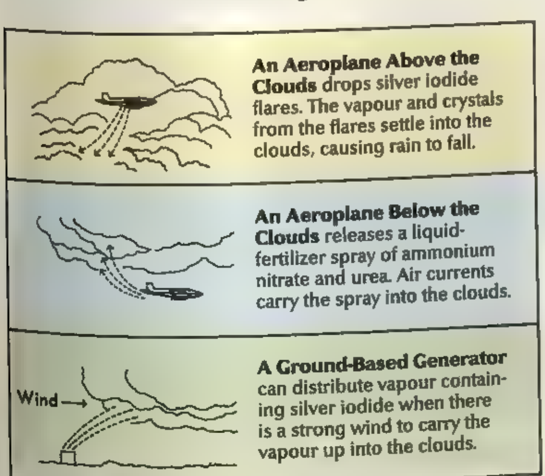
Dry ice, which is frozen carbon dioxide, has a temperature as low as −80° C. When dropped into a cloud from an aeroplane, pellets of dry ice reduce the temperature of supercooled water. The lower temperature makes the water form ice crystals. Silver iodide crystals resemble crystals of ice and cause supercooled water to form ice crystals around them.

Devices called *flares* and *generators* are used to produce and distribute a vapour containing silver iodide crystals. The vapour is made by burning silver iodide with other substances. It is usually distributed from an aeroplane, though generators also may be used to distribute it from the ground.

Arguments about rainmaking. Cloud seeding has caused much debate because scientists have not been able to demonstrate its effectiveness in all cases. In addition, some people believe increased rainfall in certain areas might cause shortages of rain elsewhere.

See also **Snow** (Artificial snow).

Three methods of rainmaking



Raisin is a dried grape. The word *raisin* comes from a French term meaning *dry grape.* Varieties of white grapes that have tender skin, rich flavour, and high sugar content are especially suited for making raisins. Raisins are used in puddings, cakes, sweets, biscuits, and bread. They are also sold as sweets or may be coated in chocolate.

Raisins have been a food delicacy since ancient times. The Egyptians first discovered that drying fruit preserved it, made it sweeter, and improved its flavour. The Bible mentions that an Israelite brought cheese and raisins to pay his taxes to King David. Wealthy Romans served raisins at feasts.

Spanish missionaries planted grapevines in California, U.S.A., during the 1700's. Soon after the American Civil War ended in 1865, former gold hunters discovered that the region of California now called the Central Valley had an ideal climate for producing raisins. The dry, hot summers allowed for grapes to ripen, and the low chance of rain after the harvest meant that the grapes could be sun-dried in the vineyard. Commercial raisin production in California began in the 1870's.

The largest producer of raisins in the world is Turkey, with an estimated 400 million kilograms a year. California is second, producing 300 million kilograms, and Greece, another large producer, is third. Australia and Iran are also leading producers of raisins.

Varieties of raisins. Four main varieties of grapes are used in raisin production. The most common is the Thompson Seedless. Seedless grapes used to make raisins were first grown in Turkey. In 1872, William Thompson introduced seedless grape cuttings to California. Other varieties include Muscat of Alexandria, Black Corinth, and Sultana. The Muscat is a large, seed-bearing grape taken to America by Spanish missionaries. Grapes from Black Corinth vines are used to make Zante currants—tiny, seedless raisins used mainly to flavour baked goods. Raisins made from Sultana grapes, which are seedless and have a distinctive flavour, are also used mainly in baked goods.

Growing grapes. In the Northern Hemisphere, grape vines generally start growing in March, and the fruit is harvested at the beginning of September. The vineyards must be irrigated because little rain falls in the area during the period when the vines grow. Vines used for raisins are generally planted in rows that run in an east-west direction. They must be spaced far enough apart to allow room for drying the fruit and to permit cultivation. Grapevines begin bearing fruit in three years. With proper care, they may continue to produce fruit for 100 years. About 2 kilograms of grapes produce 0.5 kilogram of raisins.

Preparation for market. Seedless grapes ripen on the vine until sugars account for more than 20 per cent of their weight. They are harvested by hand or machine and placed on trays of heavy, brown paper between the rows of vines. The fruit may be turned over after about eight days so that grapes on the bottom can dry faster. The sun dries the grapes in 10 to 14 days. The raisins are then stored in large bins, called *sweat boxes,* to equalize their moisture content. Next, the fruit is sent to packing houses.

In a packing house, workers stem and grade the raisins by passing them over screens. Machines remove stem caps. A machine whirls the raisins through a fine spray of water to give them a final cleaning. The raisins are then pressed into sealed packages.

Raisins with seeds go through a slightly different process. Muscat raisins are larger and softer than the seedless types after drying. They are passed through the stem-removal machine and washed in hot water to soften them further. They are then fed between rubber rollers that press the seeds to the surface. A saw-tooth roller catches the seeds in its teeth and removes them.

Sun-dried raisins are called *natural raisins.* Most raisins are natural. However, golden seedless or golden raisins, made from Thompson Seedless grapes, are dried in large machines. The grapes are first treated with sulphur dioxide to preserve their golden colour.

Because of their high sugar content, raisins need no preservatives to keep them fresh. If raisins are kept cool and stored in a sealed container, they will retain their flavour, colour, and nutritional value for up to 15 months. They may also be frozen.

Food value. Raisins are a good source of vitamin A, the B vitamins thiamine and riboflavin, and such minerals as calcium, iron, and potassium. They also contain sugar, which gives quick energy.

See also **Grape.**

Rajagopalachari, Chakravarti (1879-1972), was an Indian nationalist leader. He was popularly known by his initials, "C.R." He served as governor general of India from 1948 to 1950.

Rajagopalachari was born into an orthodox Brahmin family at Hosur, in what is now the Indian state of Tamil Nadu. He was educated in Bangalore and qualified as a lawyer. In 1919, he met the Indian leader Mohandas Gandhi and joined the nationalist movement. He served as a Congress Party official, and led the civil disobedience campaign against the British government in 1930 (see **Dandi march**).

Rajagopalachari served as chief minister of Tamil Nadu from 1937 to 1939, and from 1952 to 1954. He promoted religious tolerance, equal opportunities, and the prohibition of alcohol. During World War II (1939-1945), he supported the British. Rajagopalachari inaugurated the ingenious "C.R. formula," which accepted Muslim-majority provinces within the framework of an independent, federal India.

Indian independence was achieved in 1947. After a few years, Rajagopalachari moved away from the Congress Party. He was a founder member of the Swatantra

The City Palace at Udaipur, Rajasthan, stands beside the Pichola Lake, a 4-kilometre long, man-made reservoir. Two other Rajput palaces stand on islands in the lake.

Party, which supported free enterprise and closer ties with the West.

Rajah is a title taken from the Sanskrit word *rajan*, which means *king*. Ruling princes of native states in India were once the only persons known as rajahs. But under the British Empire the title of rajah was also given to certain other high-ranking Hindus. Native princes who kept some authority under British rule were called *maharajah* (great king).

Rajaraja I was probably the greatest ruler of the Chola Empire in southeastern India. He reigned from 985 to 1016. The centre of his empire was the delta of the Kaveri River, in what is now the modern Indian state of Tamil Nadu. During his 30-year reign, he expanded his kingdom into an extensive empire with a powerful standing army and navy.

He began by conquering the neighbouring Pandiya and Kerala kingdoms. Later he invaded the island of Sri Lanka to the east, destroying Anuradhapura and turning Polonnarava into a Chola province. He also annexed the Maldive Islands to the west of India.

Rajaraja's chief monument is the temple of the Hindu god Shiva as Brhadisvara. The temple is at Thanjavur, in the Cauvery River delta. This temple, completed in 1014, has a tower 64 metres high, capped with a carved stone weighing about 80 metric tons.

See also Chola Empire.

Rajasthan is a state in the northwest of India. It is the second largest state in the country. Rajasthan means "the land of the rajahs (or kings)". It was also called *Rajputana*, "the country of the Rajputs" (a group of clans). The state has a long border with Pakistan, and contains a large area of desert.

People and government

People. Today, tribal people make up more than 12 per cent of the state population. The main tribes are the Bhils and Minas. The smaller ones include the Sahariyas, the Damariyas, the Garasias, the Gadia Lohars, and the Bhil-Minas. The tribes share common characteristics, which seem to link their pasts together. But differences in costumes, jewellery, gods, and festivals set them apart from one another.

The Bhils form an important group in the southern part of the state around Dungapur, Udaipur, and Chitorgarh. Their stronghold is Banswara. Their name derives from *bil* (bow) which describes their original talent and strength. The Hindu epic the *Mahabharata* mentions the Bhils and their archery skills (see **Mahabharata**).

The Minas are Rajasthan's largest and most widely spread tribal group. In the north, they inhabit the Sikar belt of Shekhavati. In the southwest, the Mina settlements mix with the Bhils of Bundi-Kota-Jhalawar.

The Gadia Lohars are *nomadic* blacksmiths, who travel from place to place. Their name derives from their beautiful *gadis* (bullock carts). The Garasias are probably descendants of the Chauhan Rajputs of Jalore in southwest Rajasthan. The Sahariyas are jungle dwellers.

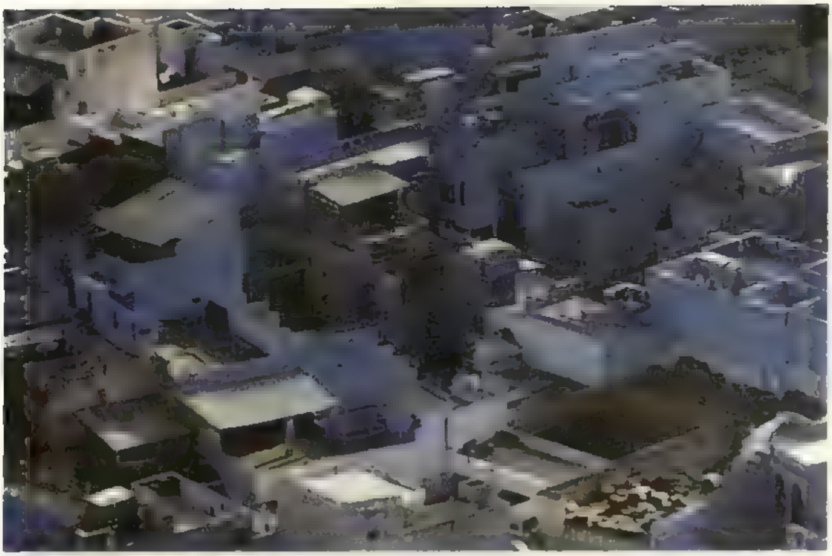
The Rajputs are an important section of the population, though they only represent a small percentage of the people of the state. The Rajputs claim to be the original *kshatriyas* (warriors) of the ancient *varna* system (Hindu division of society). They are probably descendants of the Huns and Scythians who entered India in the 500's. The Jats are people living in the north and west of Rajasthan and are primarily an agricultural people. They are prominent in Bharatpur and Dholpur. The Gujars are mostly cattle breeders and are found in the eastern part of the state. The Kathodis inhabit the forest tract of the Aravalli range. The Sahariyas lead a primitive life while the Rebaris are cattle breeders.

The state's main language is Rajasthani, which comprises a number of Indo-Aryan dialects. The four most important of these are Marwari (west), Jaipuri (east), Malwi (southeast) and Mewati (northwest). Hindi is rapidly replacing Rajasthani as the main language.

Hinduism is the religion of most people in Rajasthan. Jainism is also significant. Islam extended into the region with the conquest by Ajmer in the 1100's, and is still

Rajasthani women choose colourful bangles. Jewellery, embroidery, and costume distinguish Rajasthan's many tribes.

Rajasthan is a state in northwestern India. It is bordered on the west by Pakistan.



Houses in Jodhpur are built close together. These blue-painted buildings are the homes of people of the Brahmin *caste* (social division).

widely practised. Sikhs and Christians form extremely small minorities.

Rajasthan is one of the least densely populated states in India. It is also one of the poorest. Large numbers of people, especially women, are unable to read or write.

The state's economy depends mainly on agriculture. But the state also has good mineral resources. Tourism makes a large contribution to the regional economy.

Government. The head of state is the governor, who is appointed by the president of India for a five-year term. The legislative assembly in Jaipur, the state capital, has 200 members. They include representatives of the tribal groups.

Rajasthan has 25 elected members of the *Lok Sabha* (lower house) and 10 nominated representatives in the *Rajya Sabha* (upper house) of the Indian national parliament.

The state is divided into 27 districts. The district collector is the principal administrator and coordinates the activities of various departments. Rajasthan was the first state to experiment with the *panchayat raj* (village council) system of government.

Economy

Agriculture. The total cultivated area of Rajasthan is about 19 million hectares, of which only about 20 per cent is irrigated. Most of the farmed area depends on rainfall, which is low and unreliable. In the drier areas, the main crops are *bajra* (millet), oilseeds, tobacco, and wheat. Elsewhere, *jowar* (sorghum), maize, and pulses, such as peas, beans, and *gram* (lentils) are grown. Cotton is an important cash crop.

Rajasthan receives water from the Punjab rivers in the west and the Narmada in the south. The Gurgaon canal supplies water from Haryana and the Agra canal brings water from Uttar Pradesh. The state shares the Bhakra Dam project with Punjab. The Chambal Valley project (Do Kota Barrage and Rana Pratap Sagar) is shared with Madhya Pradesh. The largest canal within the state is the Indira Gandhi (formerly Rajasthan) Canal.

Farmers graze livestock in some areas too dry for cultivation. Rajasthan has a large livestock population, including camels. It is India's largest wool producing state.

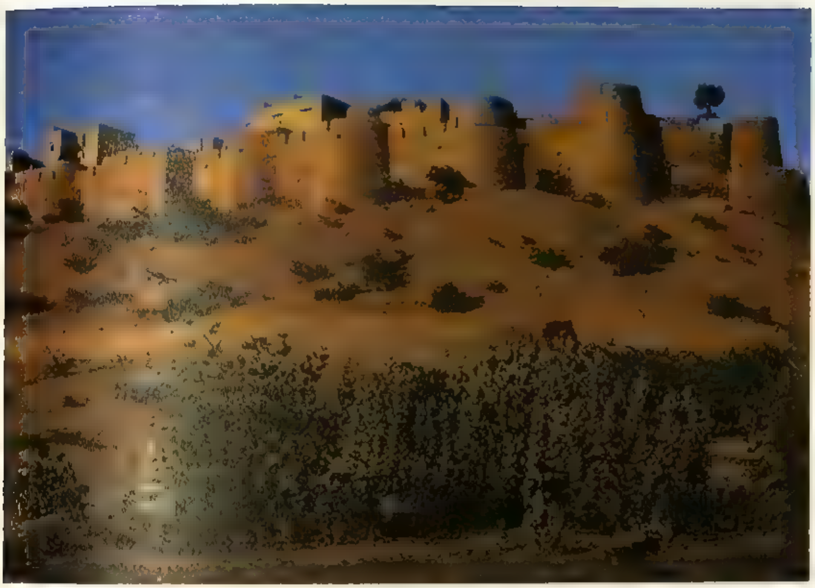
Manufacturing. The main products are dyes, textiles, rugs and woollen goods, and vegetable oil. Heavy industry includes the construction of railway rolling stock, and copper and zinc smelting. The chemical industry produces calcium carbides, caustic soda, and sulphuric acid. Chemical plants also manufacture fertilizers, insecticides, and pesticides. There is a rapidly expanding light industry, which includes assembling television sets. Precision instruments are manufactured at Kota. The main industrial complexes are at Jaipur, Kota, Udaipur, and Bhilwara.

Traditional handicrafts include pottery, jewellery, marble work, embossed brass, block printing, embroidery, and decorative painting. They are now popular with foreign buyers.

Mining. Rajasthan accounts for the country's entire output of emeralds, garnets, and zinc concentrates. It also produces about 84 per cent of India's asbestos, 68 per cent of its feldspar, 94 per cent of its gypsum, 12 per cent of its mica, and 76 per cent of its silver ore. The state has rich salt deposits at Sambhar and other places. There are copper mines at Khetri and Dariba. The white marble used to build the Taj Mahal was mined at Makrana near Jodhpur.

Facts in brief about Rajasthan

Population: *1991 census*—43,880,640.
Area: 342,239 km².
Capital: Jaipur.
Largest cities: Jaipur, Udaipur, Jodhpur.
Chief products: *Agriculture*—barley, cotton, millets, oilseeds, pulses, wheat, and wool. *Manufacturing*—fertilizers, precision tools, textiles. *Mining*—asbestos, emeralds, garnets, gypsum, salt, silver ore, zinc.



Jaisalmer Fort, built in 1156, rises dramatically from the desert. Inside the walls lie the narrow streets of the old city, a group of Jain temples, and a former palace.

Transportation. Rajasthan has about 50,000 kilometres of road, of which 15,000 kilometres is national highway. The rail system extends to Jaisalmer and Barmer on the edge of the Thar desert and provides good connections with Bombay and Delhi. It also serves the neighbouring states of Madhya Pradesh and Gujarat. Ajmer, Bikaner, Jodhpur, Jaipur, and Kota are the main junctions. Air services link the major centres and connect them with the neighbouring states. They also serve Bombay and Delhi.

Tourism. Rajasthan is one of India's most popular tourist destinations. Its attractions include temples, forts, palaces, and nature reserves. There are camel safaris from Jaisalmer. Visitors can also travel on the Palace on Wheels luxury train, which was once the property of various princes.

Land

Location and description. Rajasthan shares an international border on the west and northwest with Pakistan. Punjab and Haryana border it to the north, Uttar Pradesh to the east, Madhya Pradesh to the east and southeast, and Gujarat to the south and southwest. South of Banswara, Rajasthan lies within the Tropic of Cancer.

Land features. The Aravalli hills run from Mount Abu in the southwest to Khetri and beyond in the northeast. They divide the state in half and rise to 1,700 metres. To the northwest is the Thar desert. This region is arid, sandy, and far less productive than the land to the southeast. Around Mewar the land is hilly. It is flat around Bharatpur and forms part of the Jumna (Yamuna) drainage basin. There is a plateau near Kota and Bundi.

The soils in the northwest of the state are dry, and sandy. They are more fertile on the eastern and northeastern margins. In Jaipur and Alwar, in the centre and west of the state, the soils are sandy and loamy. Only around Kota and Bundi are there good, black, deep, and well drained soils.

Climate. The climate varies widely in Rajasthan. Except in the hills, the summer temperatures are extremely high, with a maximum of 46° C and an average from May to August of 38° C. The daily summer minimum is 25° C. In winter, the daily maximum in most low-lying areas is between 22 and 28° C, and the minimum between 8 and 14° C.

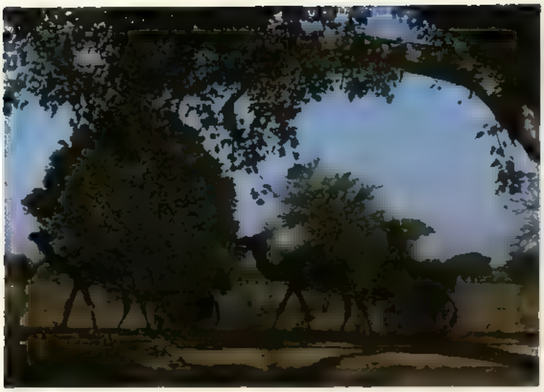
Rainfall varies over the state. Parts of the western desert receive only 10 centimetres a year. Jaisalmer has an annual rainfall of 21 centimetres, 90 per cent of which falls during the *monsoon,* between July and September (see **Monsoon**). Jaipur receives 65 centimetres of rain annually, 80 per cent of which falls during the monsoon. Jodhpur, midway between these two places has 38 centimetres of rainfall a year. The Aravalli Range receives a higher rainfall and experiences lower temperatures throughout the year. To the southwest there is a higher rainfall and high humidity.

Plants and animals. The natural vegetation of most of the state is scrub jungle. Trees are scarce, except in well wooded areas such as Kumbhalgarh in the southeast and in the eastern parts of the state. Tamarisk and arid zone plants grow in the west.

The natural jungle is ideal territory for *chital* (small spotted deer), leopards, *sambhar* (large brown deer), sloth bear, and tigers. These animals are now only rarely found outside game reserves. Black buck, *nilgai* (blue bulls), and ravine deer are fairly numerous on the plains.

The birdlife of the region is varied. Bikaner is famous for its sand grouse. Bharatpur and other low-lying swampy areas in the southeast of the state are popular winter grounds for migratory birds from Siberia and northern Europe.

Rivers and lakes. The Aravalli hills form the *watershed* (the divide between two river systems). The only major river in the northwest is the Luni, which rises in the Pushkar Valley and flows southwest to the Rann of Kutch. All the other rivers have their source in the Aravalli hills and flow to the north before joining the Luni.



Farmers in Rajasthan use camels to carry loads and, *above,* to draw cartloads of farm produce.

On the southern side of the range the Bandi, Dhund, and Mashi rivers rise between Kishangarh and Jaipur and join the Berach, flowing northeast from Eklingi to form the Banas River. The Banas is the main tributary of the Chambal River. Farther north, the Banganga flows eastward from its source near Jaipur to join the Jumna River.

Places to visit

Following are brief descriptions of some of Rajasthan's interesting places to visit.

Ajmer is a city located on a lake. The city is the site of a palace built by the Mughal emperor Akbar in 1570.

Bharatpur is a small town which is best known for its nearby bird sanctuary. More than 300 different kinds of birds including 80 different types of ducks, have been recorded in this low-lying marshy sanctuary.

Jaipur has the Amber Palace, a hill-top fort which dates from the 1700's. Jaipur City Palace was built in the early 1700's by King Jai Singh II, who was known as an architect and town planner, scientist, and historian as well as a soldier and a ruler. The city also has an open-air astronomical observatory and an elegant five-storey building known as the *Hawa Mahal* (palace of winds) from which the ladies of the Maharajah's harem were able to peek out at the world through its 593 windows and peepholes.

Jaisalmer has a fort built in the 1100's by the Bhatti chieftain Jaisal.

Jodhpur is dominated by the Meherangarh (Majestic) Fort on a 125-metre high hill in the centre of the city. The gates of the fort include those built by Maharaja Man Singh in 1806 following his victory over the armies of Jaipur and Bikaner.

Mount Abu is a hill station in a 1,200-metre high plateau in the south of Rajasthan. The main attractions of Mount Abu are the three Dilwara Jain temples about 5 kilometres from the town. The oldest temple dates from 1031.

Ranakpur has one of the largest and most important Jain temples in India. The main temple was built in 1439.

Sariska Wildlife Sanctuary is located about 100 kilometres from Jaipur. It has blue bulls, sambhar (brown deer), spotted deer, wild boars, and tigers.

Udaipur has a palace built by Maharana Jagat Singh II in 1754. It covers the entire island of Jagniwas and is now used as the Lake Palace Hotel. The huge City Palace beside the lake was originally commenced by Maharana Udai Singh, who founded the city in 1657. It is now used as a museum.

Nearly all the lakes in the state are artificial reservoirs. The most famous is the Pichola Lake at Udaipur, in the middle of which is the former summer palace of the Maharanas. It is now a luxury hotel.

History

Prehistoric human groups lived along the Banas River 100,000 years ago. Archaeologists have found evidence of the Harappan and post-Harappan cultures, which flourished around 2500 B.C. (see **Indus Valley Civilization**). Some of the pottery at Kali Banga dates from 2700 B.C.

Rock inscriptions discovered near Bairat reveal that the Maurya emperor Asoka controlled part of the state in about 250 B.C. (see **Asoka**). The Mauryas were followed by the Bactrian Greeks, the Scythians, the Guptas, and the Huns.

Rajput dynasties rose to political supremacy between the 600's and the 1200's. The Rajputs were a heroic warrior caste who lived by a strict code of chivalry and ritual. Upon the arrival of Islam in India, the Rajasthan region became a Hindu stronghold. Rajput strength reached its peak in the early 1500's before the Mughal Babur defeated armies of Rajputana (see **Mughal Empire**).

Akbar, in a move to make peace with the Rajasthanis, married a Rajput princess and enlisted the services of Rajput nobles in his imperial service. Those kings who did not serve Akbar were conquered.

In the 1700's, Marathas, Pathans, and Pindaries all threatened Rajasthan. The Rajput rulers appealed for aid to the British East India Company. In the 1800's, British influence gradually extended into the state. The British allowed the princes of the independent states to run the internal affairs of their territories as they wished. But

Jaipur, the state capital of Rajasthan, is a walled city and a major tourist attraction.

a British representative controlled external matters. He was responsible to the political officer for the whole province, who in turn answered to the governor. British troops helped the native rulers put down peasant rebellions during the period.

Ajmer became one of the centres of nationalist activity. When India gained independence in 1947, Rajasthan was an important part of the newly independent country. The princes gradually surrendered their powers to the central government and became ordinary citizens in 1971. The Bharatiya Janata Party (BJP) controlled the state in the early 1990's.

Related articles in *World Book* include:

Akbar	Jaipur
India, Government of	Mughal Empire
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Outline

I. People and government
- A. People
- B. Government

II. Economy
- A. Agriculture
- B. Manufacturing
- C. Mining
- D. Transportation
- E. Tourism

III. Land
- A. Location and description
- B. Land features
- C. Climate
- D. Plants and animals
- E. Rivers and lakes

IV. History

Rake is a machine used to gather mowed hay and place it in long piles called *windrows*. The windrows are then gathered by a hay loader or baler. The first rakes were wooden hand rakes. People still use hand rakes to rake leaves from lawns. Modern rakes are of many types, and are usually pulled by, or mounted on, a tractor. Rakes can also be used to gather straw, green forage, and seed crops.

A dual rake consists of two rakes hitched to a tractor. As the dual rake is pulled along by the tractor, it gathers mowed hay and deposits it into long rows called *windrows*.

The dump rake consists of curved steel teeth mounted on an axle between two wheels. The teeth slide over the ground and rake hay as the machine moves forward. The operator dumps the hay in a windrow by pulling a lever that causes the teeth to lift from the ground.

The side-delivery rake leaves the hay in a continuous windrow at the side of the vehicle carrying the rake. In one type of side-delivery rake, the teeth are attached to cylinders that roll along at an angle to the direction travelled. The teeth just clear the ground as the cylinder rotates. As the machine moves ahead, the teeth brush the hay to the side, leaving it in a windrow. A *dual rake* consists of two side-delivery rakes, which deposit two windrows together at one time.

The *finger-wheel rake* consists of several wheels with spikes on the rim. The wheels are set at an angle to the direction travelled, and move the hay sideways to form a windrow. The *drag-type rake* has no moving parts but it has curved fingers that move the hay to one side.

Raleigh, Sir Walter (1552?-1618), is one of the most colourful figures in English history. He was a soldier, explorer, writer, and businessman.

Raleigh was born at Hayes Barton, a family home in Devonshire, and attended Oxford University. He left university before graduating to join a band of gentlemen volunteers who were helping the Huguenots in France (see **Huguenots**). In 1578, he returned to England and joined his half brother, Sir Humphrey Gilbert, on a voyage of discovery and piracy.

Raleigh and Elizabeth I. In 1580, Raleigh became a captain in the army in Ireland. There he distinguished himself by his ruthlessness at the siege of Smerwick. The next year, he went to Queen Elizabeth's court with dispatches (see **Elizabeth I**). There is a famous story about his meeting with Elizabeth. The queen was out walking, and stopped before a large mud puddle. Raleigh removed his cloak and placed it over the puddle for her to walk on. It is doubtful that this story is true. However, Raleigh did become the queen's favourite. Elizabeth granted him an estate of 4,860 hectares in Ireland. She also gave him trade privileges and the right to colonize in America. In 1585, Elizabeth made Raleigh a knight.

His expeditions. Raleigh became deeply interested in exploration, like many prominent English people of his day. He sent several expeditions to America, and spent a fortune trying to establish an English colony there. His settlers landed in what is now the state of North Carolina and explored the coast as far as present-day Florida. Raleigh named this entire region *Virginia* in honour of Elizabeth, known as "The Virgin Queen."

Raleigh's first colonizing expedition left Plymouth in April 1585. But sickness and fear caused the survivors of this first English colony in North America to go home with Sir Francis Drake in 1586.

In 1587, Raleigh sent a second expedition. A group of 117 colonists, including 17 women, landed on Roanoke Island. On Aug. 18, 1587, the first English child was born in North America (see **Dare, Virginia**). John White, the governor, went back to England for supplies. He was delayed by war with Spain, and when he returned to Roanoke in 1590, the settlers had mysteriously disappeared (see **Lost Colony**).

Oil painting on canvas (1588) by an unknown artist

Sir Walter Raleigh was an adventurer and explorer, and a leading figure in Britain's Elizabethan age.

Raleigh also took part in the victory over the Spanish Armada in 1588. He led other expeditions against Spanish possessions and returned with much booty. During the 1590's, his power reached its height, and he had much influence and many enemies. Raleigh, who was also a poet, obtained a pension for the English poet Edmund Spenser and helped Spenser publish *The Faerie Queene* (see **Spenser, Edmund**). Raleigh also helped introduce the potato plant and tobacco use to Ireland.

His fall. Raleigh lost the queen's favour by marrying one of her maids-of-honour. Hoping to recover his position and the money he had spent, he led an expedition to Guiana, in South America, to search for El Dorado, a legendary land of gold. But the expedition failed.

Elizabeth died in 1603, and the new king, James I, distrusted and feared Raleigh. He charged Raleigh with treason, and imprisoned him in the Tower of London. There Raleigh lived comfortably for 12 years with his family and servants, and wrote his *History of the World*. He was released in 1616 to lead an expedition to search for gold in South America. The king ordered him not to invade Spanish territory. But Raleigh's men attacked the Spaniards. Raleigh's son Wat was killed in the attack, and Raleigh was forced to abandon the project.

Upon his return to England, he was sentenced to death for disobeying orders. Raleigh met his fate bravely. He joked with the executioner, and even gave the signal for the axe to fall.

Ram. See **Sheep** (The body of the sheep); **Aries; Battering ram.**

Rama is the hero of the Indian epic poem *Ramayana* (see **Ramayana**). He is also popular in *wayang* (shadow theatre) in Indonesia, where he has captured people's imagination with his romantic adventures and fantastic wars against evil. Rama is popular in the theatre and literature of Indonesia. To the Balinese especially he is an idol, a hero, a model of conduct, and an ideal of the race.

Ramadan, the ninth month in the Muslim year, is the holy month of fasting. The Islamic calendar is based on the moon, so the date of Ramadan changes from year to year. Thus Muslims fast in different seasons as the years go by. In the month of Ramadan, Muslims do not eat or drink during the daylight hours from dawn to sunset. They also refrain from sexual intercourse during these hours.

Muslims fast in obedience to God's command in the Muslim holy book, the Quran, and to atone for their sins. Rich and poor people fast during Ramadan. People who cannot fast, such as travellers, the sick, nursing mothers, and soldiers, are exempt. In the daytime during Ramadan, Muslims pray, read the Quran, and rest. After sunset they may eat and drink. The last ten days of Ramadan are held to be especially sacred. Ramadan ends with the new moon, and Muslims mark the end of the fast with thanksgiving prayers and celebrations during a three-day Festival of the Breaking of the Fast, *Id al-Fitr*.

Ramakrishna (1836-1886) was an Indian religious leader. He never wrote down his beliefs, but his followers recorded his ideas. His teachings have been published in many parts of the world. They led to the establishment of the Ramakrishna Mission in Calcutta. The mission carries out educational and charitable work throughout India. Its branches have spread to Southeast Asia, Europe, and the United States.

Ramakrishna was born into a poor Brahmin family in Bengal. His original name was Gadadhar Chattopadhyaya. He took the name of Ramakrishna after becoming a holy man. He became a priest at a Kali temple near Calcutta, where his elder brother served as senior priest. Ramakrishna had little formal education, and spoke only basic village Bengali all his life. He suffered from epileptic fits from childhood onwards, and would fall into trances. At such times he had visions of the goddess Kali. He also claimed to see Muhammad, prophet of Islam, and Jesus Christ. These experiences convinced him of the truth and oneness of all religions. He believed that they were merely different paths all leading to the same destination.

Throughout his life, Ramakrishna had moods that left him either supremely happy or deeply depressed. When he was in his twenties, he married a five-year-old girl called Sarada Devi, but they never lived together. He saw his wife as the image of the goddess Kali, whom he worshipped continually. Ramakrishna followed the practices of yoga, and regarded caste distinctions and riches as great evils (see **Caste**).

Raman, Sir Chandrasekhara Venkata (1888-1970), an Indian physicist, discovered that when a beam of light passes through a liquid or a gas, it is scattered and the frequency of some of the scattered light is changed. This change, which is called the *Raman effect*, provides a way for studying the structure of the scattering molecules. For his discovery, Raman was knighted in 1929 and received the 1930 Nobel Prize for physics.

Raman was born in Trichinopoly (now Tiruchchirappalli). He founded the *Indian Journal of Physics* and the Indian Academy of Sciences. After 1930, he mainly studied the structure of crystals.

Ramanuja (1017?-1137?) was an Indian philosopher and religious teacher of devotional Hinduism. He belonged to the Vaishnava sect of Hinduism, members of which worship mainly the god Vishnu. Ramanuja understood Vishnu to be the supreme creator, all-powerful, perfect, and full of love and concern for humanity. Vishnu has many forms. Ramanuja believed that Rama, the righteous king, was the greatest of these Vishnu forms. Ramanuja also believed that each soul retained its individual identity after death, although it was dependent on God and very near to God. The powerful rulers of Tamil Nadu in southern India worshipped the god Shiva. These rulers taught that when a person died his or her soul merged with the supreme being or God. As a result, they persecuted Ramanuja for his different religious beliefs.

Ramanuja was born in southern India into a scholarly Brahmin family. When Ramanuja was just a boy his father died. Later, Ramanuja made an unhappy marriage. He finally left his wife to become a holy man, practising self-denial. He made a long pilgrimage to the holy places of northern India before returning to Shrirangam in Tamil Nadu. There, Ramanuja gathered as many as 74 disciples to carry his teachings far and wide. Shrirangam is now a famous pilgrim site.

Ramanuja opposed the priests' claim that they were the only people divinely authorized to teach the scriptures and to perform holy ritual. He boldly preached to people of all castes and of no caste (see **Caste**). He welcomed into his order everybody who wished to join. He encouraged the education of women, and preached equality of the sexes in social and religious matters.

Ramanujan, Srinivasa (1887-1920), was an Indian mathematician. He was born in Erode, in the Indian state of Tamil Nadu. His mathematical ability and powers of memory were outstanding even as a child. But Ramanujan concentrated so much on mathematics, to the exclusion of other subjects, that he eventually lost his scholarship at Government College in Kumbakonam.

In 1911, Ramanujan obtained a minor post with the Madras Port Trust and continued to educate himself. He entered into correspondence with Professor G. H. Hardy of Cambridge University, in the United Kingdom. This correspondence eventually led to Ramanujan being invited to Cambridge as a research scholar in 1914.

In 1918, Ramanujan became only the second Indian to be elected a Fellow of the Royal Society. He also became a fellow of Trinity College, Cambridge. Sadly, his health declined in the unfamiliar climate and in 1919, he returned to Madras. He died soon after.

Ramaphosa, Cyril (1952-), a former black South African trade union leader, became secretary general of the African National Congress (ANC) in July 1991. He headed the ANC delegation in negotiations with the South African government and other political groups over the drafting of a new South African constitution.

Matamela Cyril Ramaphosa was born in Johannesburg. He became active in politics while studying law at the University of the North, Turfloop, Transvaal. In 1974, he became chairman of the South African Students' Organization (SASO). Between 1974 and 1976, he was twice jailed without trial under the Terrorism Act for a total of 17 months. In 1981, Ramaphosa joined the legal department of the Council of Unions of South Africa. In 1982, he became general secretary of the South African National Union of Mineworkers (NUM) and later helped set up the Congress of South African Trade Unions (COSATU). In 1987, Ramaphosa led the whole NUM in a massive three-week strike. In the same year, Sweden awarded him the Olaf Palme Memorial Prize.

Ramapithecus was a kind of ape that lived from about 14 million to 8 million years ago. Many scientists once believed that it was the earliest direct ancestor of human beings. Today, most scientists no longer believe that *Ramapithecus* was related to human beings. Instead, they think it was probably an ancestor of the orangutan, a large type of ape that lives in Asia. *Ramapithecus* probably lived in partially wooded areas and ate such foods as nuts, roots, and seeds.

Remains of *Ramapithecus* were first discovered by the American anthropologist George E. Lewis in 1932. That year, Lewis found parts of a jaw and some teeth from this creature in an area of northern India that is now part of Pakistan. He named the creature *Ramapithecus,* which means *Rama's ape*. The name comes from *Rama,* a mythical prince of India, and the Greek word *pithekos,* meaning *ape*. More fossil jaws and teeth of *Ramapithecus* were found later in China, Greece, Hungary, India, Kenya, Pakistan, and Turkey.

Until the late 1970's, many scientists classified *Ramapithecus* as a *hominid*. A hominid is a member of the family made up of human beings and humanlike creatures. The scientists believed that *Ramapithecus* gradually developed into *Australopithecus,* a hominid that lived in Africa (see **Australopithecus**). Since the late 1970's, more complete fossil remains of *Ramapithecus* were found in China and Pakistan. These fossils indicated that *Ramapithecus* was not a hominid but an ape.

Ramayana is one of the two great epic poems of India. The other is the *Mahabharata*. The hero of the *Ramayana* is Rama, the son and heir of an Indian king (see **Rama**). Rama was born in the kingdom of Ayodhya (formerly Oudh, now part of Uttar Pradesh). Visvamitra, his wise schoolmaster, taught him the ideals he should follow on becoming king.

As a young man, Rama competed with other suitors for the hand of Princess Sita at the court of her father, King Janaka. By drawing the great bow of the god Shiva, he proved worthy to win the princess's hand in marriage. The couple returned to Ayodhya but Rama's stepmother plotted against him and, as a result, he was exiled. Sita and Lakshmana, Rama's half-brother, went with him. They all lived together in the forest.

One day Ravana, the demon king of Lanka (now Sri Lanka), sent a beautiful golden deer into the forest. Sita was delighted and asked Rama to catch it for her. The deer led him far away, and when he failed to return, Sita asked Lakshmana to look for him. Rama had asked Lakshmana to guard Sita, but on this one occasion he disobeyed his instructions in order to please Sita, and disaster followed.

After Lakshmana had gone, Sita was left alone. Then King Ravana appeared disguised as a holy man. When he begged some food of Sita, she explained that she

Rama's exile in the forest was shared by Sita and Lakshmana. In the painting, *right*, the artist has depicted each character more than once to show different aspects of their life in the forest. Rama, as was traditional, is shown as dark skinned.

Manuscript, school of Sahibdin, 1652, British Library, London

could not cross a line drawn round the house by Lakshmana. But Ravana tricked her. Sita trusted him because he looked like a holy man, but he seized her and carried her off to his court in Lanka.

When Rama and Lakshmana returned and found Sita gone, they were determined to rescue her. During their preparations they made an alliance with Sugriva, the monkey king. The monkey general, Hanuman, helped Rama to find Sita and attack Lanka. In the ensuing battle, Ravana was killed and Sita was rescued. Rama, Sita, Lakshmana, and Hanuman returned to Ayodhya rejoicing, and Rama was crowned king.

A later section of the *Ramayana* tells how some of Rama's subjects suspected Sita of being unfaithful. Although she was proved innocent, Rama banished her to the forest. There she was looked after by the hermit Valmiki, and in his hermitage she had twin sons. When the boys grew up, Rama discovered them in the forest. The family was reunited, but Sita was forced to call on the earth to testify to her fidelity to Rama. The earth swallowed her up, and Sita went straight to heaven.

Hanuman, the monkey general, helped Rama recapture his wife. He is utterly loyal to Rama throughout his life.

The poet Valmiki supposedly wrote the first version of the *Ramayana* in Sanskrit during the 300's B.C. It has 24,000 verses. Translated or rewritten versions appear in other Indian languages. The Hindi version, written by the poet Tulsi Das in the late 1500's, became the most popular.

The *Ramayana* story illustrates several ideals of human behaviour. Rama is the ideal king. He puts his duty to the people of his kingdom before his responsibility to his family. Sita is the ideal wife. No matter how many dangers she faces, she always remains faithful to her husband. Lakshmana is the ideal brother. He supports his elder brother without question, even at great loss to himself. Hanuman is the most loyal of followers. He is loyal to Rama through good times and bad.

The story also teaches the importance of duty and obedience. If Lakshmana had obeyed Rama and stayed with Sita in the forest, she would not have been captured. If Sita had obeyed Lakshmana and stayed in the house she would have been safe. Evil, in the form of Ravana, can have no power over those who are dutiful, faithful, and obedient.

The story of *Ramayana* has held the attention of Hindus over the centuries, and the moral lessons it contains have had a deep and lasting effect. It remains one of the most popular tales of moral perfection in Hinduism. There have been many translations, numerous films, and a television series of the epic. It is claimed that great religious merit comes from watching or listening to the *Ramayana*. Both the *Ramayana* and the *Mahabharata* form the basis of stories told through the Kathakali dance drama of south India.

The heroes of both these epics are also famous in Southeast Asia, especially in Balinese and Javanese theatre and dance. Indian sculpture and paintings portray episodes from the epics. In north India, people celebrate the annual festival of Ram-Lila, when the story of Rama's adventures is told in towns and villages to the delight of young and old. In north India, the romantic story of Rama and Sita emphasizes the inevitable triumph of good over evil, of light over darkness. That is

why Rama's victorious return to Ayodhya has become associated with Diwali, the annual Festival of Lights. Although the goddess Lakshmi is the most important deity associated with this event, the epic is celebrated in spectacular fashion as Hindu homes, temples, and public buildings are lit with thousands of lamps.

Throughout the period of Muslim rule in north India, the *Ramayana* remained a very popular theme in art, literature, drama, and music. Both the *Ramayana* and the *Mahabharata* were translated into Persian and splendidly illustrated at the Mughal court.

Throughout most of the *Ramayana,* Rama is portrayed as a human king. But according to later additions to the first and last books of the epic, he became the god Vishnu in human form. As a result, Hindus now worship him and his queen Sita, as gods. They also worship Hanuman.

See also Mahabharata; **Vishnu.**

Rambert, Dame Marie (1888-1982), helped develop English ballet. She taught and also directed her own ballet company. Marie Rambert was born in Poland. For a short time, she danced with Diaghilev's company, *Ballets Russes.* Rambert married British playwright Ashley Dukes in 1920. She opened a ballet school in 1920 and founded the Ballet Rambert dancing company in 1926, which became the Modern Dance Company in 1966.

Rambutan is a tree native to Southeast Asia which bears bright red, or sometimes yellow, edible fruit. The fruit is covered in hairs or soft spines one centimetre or more in length. The name *rambutan* comes from the Malay word "rambut" meaning "hair". The fruit are about four centimetres across. Some varieties taste sweet and sour.

Rambutan trees are bushy and grow up to 20 metres high. They have evergreen leaves between 15 and 40 centimetres long, divided into 3 to 8 leaflets.

Rambutan grows on bushy evergreen trees, native to Southeast Asia. The fruit has a sweet and sour taste.

Rambutan grows throughout the lowlands of Malaysia. It is rarely successful outside this area. A tree is either male or female and bears either all male or all female flowers. For this reason, rambutan is said to be *dioecious.* Only the female trees bear fruit.

Scientific classification. Rambutan belongs to the soapberry family, Sapindaceae. It is *Nephelium lappaceum.*

Rameau, Jean-Philippe, (1683-1764), was a French composer and musical theorist of the baroque period. Rameau worked as an organist for about 20 years in several cities before settling in Paris in about 1722. He became famous that year with the publication of a book of music theory called *Treatise on Harmony.* The book became a landmark in the history of harmony and was the first of several works he wrote on harmony.

At the age of 50, Rameau began a new career as an opera composer. He wrote more than 25 operas and opera-ballets, beginning with the opera *Hippolyte and Aricie* (1733). His major opera-ballets included *Les Indes galantes* (1735) and *Les Fêtes d'Hébé* (1739). His operas include *Castor and Pollux* (1737) and *Dardanus* (1739, 1744). Rameau's operas were controversial because of their unconventional use of orchestral colour, vivid harmonies, and speechlike singing called recitative. Rameau engaged in a quarrel with the philosopher Jean-Jacques Rousseau, largely over the preferred style of opera. Rameau favoured the French style, and Rousseau supported opera in the Italian fashion.

Rameau was born in Dijon. In addition to his theoretical writings and compositions for the stage, he wrote many suites for an early keyboard instrument called the harpsichord. In 1745, Rameau was appointed chamber music composer to King Louis XV.

See also **Opera** (French opera).

Rameses II. See **Ramses II.**

Ramie is a perennial plant grown chiefly for its fibre. It is native to Asia and is grown chiefly in India, China, and Taiwan. Ramie is one of the oldest known natural sources of fibre. There are over 30 known varieties of ramie. The most common kinds come from China and Japan. The thick, broad leaves of the ramie plant are dark green on top, and white and woolly underneath. Growers plant pieces of the roots, which grow into plants in about three months. The stalks grow from 1 to 2 metres high.

In Asia, workers strip the tough ramie fibre from the stalks by hand. The fibre at this stage is often called *China grass.* Then it is washed and dried several times to remove the gums, pectins, and waxes. Machines harvest it and strip it of its bark and core. Chemicals remove gummy material and impurities from the fibre.

Ramie's strength increases greatly when it is wet, so it is suitable for life rafts, ropes, canvas, and nets. Other uses include surgical dressings, towels, air-conditioning filters, and fabrics. However, synthetic fibres have largely replaced ramie fibres in these products, especially in industrial nations. Farmers in some Central American regions have used ramie as a high-protein fodder for pigs.

Scientific classification. Ramie is in the nettle family, Urticaceae. It is classified as *Boehmeria nivea.*

See also **Boehmeria.**

Ramjet. See **Jet propulsion** (Ramjet).

Ramlee, P. (1929-1973), was a talented Malaysian singer, actor, scriptwriter, and film director. During his career, he appeared in almost 200 films, and directed nearly 50 films. He wrote more than 1,000 songs. Most of them became top hits in Malaysia and Singapore.

Ramlee's films included *Hang Tuah,* which dealt with the legendary Malay hero of that name. Among his other films were *Penarik Beca (Trishaw Peddler)* and *Antara*

Dua Darjat (Between Two Social Classes). His comedy series such as *Bujang Lapok (Old Bachelors)* and *Labu Labi* became box office successes.

In 1957, he won the best actor award in the Asian Film Festival for his role in *Anak Ku Sazali (My Son Sazali).* In 1963, he won the award for the most versatile talent for his film *Ibu Mertua Ku (My Mother-In-Law).*

Ramlee, whose original name was Teuku Zakaria bin Teuku Nyak Putih, was born in Penang. He was educated at the Malay School, Kampung Jawa, and at Penang Free School. He began his career in the film industry in 1948. In 1961, he married Saloma, a popular Malaysian singer.

Ramos, Fidel Valdez (1928-), became president of the Philippines in June 1992. Ramos is the first Protestant to be elected as president of the country, where 80 per cent of the people are Catholic. He succeeded Corazon Aquino, who became president in 1986 after an election in which she had forced the resignation of Ferdinand Marcos.

Fidel Ramos

Ramos was born in Ansingan, in Pangasinan province. In 1950, he was a graduate of West Point Military Academy in the United States. Under President Marcos he became commanding general of the Philippines Constabulary in 1972, and was vice chief of staff of the armed forces. In 1986, Ramos supported Aquino's bid for the presidency and became chief of staff during her administration. In November 1986, he demonstrated his loyalty to the new president by refusing to join a right wing attempt to overthrow the government.

Ramp, or *wild leek,* is a wild onion that grows in moist woodland areas in the eastern United States. The flat leaves grow from the ground in spring and disappear by summer. Then a leafless flowering stem appears, bearing several greenish-white flowers at its tip. The plants smell and taste like onions. Some people believe that the Indian word *checagou,* from which Chicago got its name, refers to the smell of the ramp.

Scientific classification. Botanists consider the ramp a member of either the amaryllis family, Amaryllidaceae, or the lily family, Liliaceae. The plant's scientific name is *Allium tricoccum.*

See also **Onion; Leek.**

Rampart. See Castle.

Rampolla, Mariano Cardinal (1843-1913), Marchese del Tindaro, became a cardinal of the Roman Catholic Church and papal secretary of state in 1887. He shared responsibility for Pope Leo XIII's policy of reconciling French Catholics to their country's republican form of government. His efforts displeased not only the French monarchists, but also Emperor Francis Joseph of Austria-Hungary. The emperor took extraordinary action in 1903, when the College of Cardinals met to elect a new pope. He registered a veto of Cardinal Rampolla. The exact effect of the emperor's veto cannot be known, because popes are elected by secret vote. However, it seems likely that the veto prevented the choice of Rampolla, whose ability was well known.

Rampolla was born at Polizzi, Italy. He was ordained a priest in 1866. At the Vatican seminary, he showed such ability, particularly in Oriental languages, that he was chosen for a career in Vatican diplomatic service.

Ramsay, Allan (1713-1784), was a British portrait painter. His best portraits are of women, and show a fine and delicate style. Ramsay corresponded with famous writers of the day, including Rousseau and Voltaire. Some of his paintings hang in the National Gallery and the National Portrait Gallery, in London.

Ramsay was born in Edinburgh, Scotland, the eldest son of the poet of the same name. After studying art in Edinburgh and London, he went to Italy, where his work was held in high esteem. Settling in London in about 1762, he became portraitist to George III.

Ramsay, Sir Bertram Home (1883-1945), was an admiral in the navy of the United Kingdom (UK). During World War II (1939-1945), he commanded the naval phase of Allied landings in Normandy on D-Day, June 6, 1944. Earlier, he had directed the UK withdrawal from Dunkerque in 1940. He also commanded the naval planning and landings of Allied forces in North Africa and Sicily in 1942 and 1943.

Ramsay was born in London. During World War I (1914-1918), he served in the Dover patrol. He retired from the Navy in 1938, but was recalled in 1939.

Ramsay, Sir James (1916-1986), a retired Australian Navy commodore, was governor of Queensland from 1977 to 1986. He was governor of Western Australia from 1974 to 1977. James Maxwell Ramsay was born and educated in Hobart. He began his career at the Royal Australian Naval College at Jervis Bay. He served on several ships during World War II (1939-1945), then held a number of important posts after the war. Before his retirement, he was naval officer commanding the Western Australian area from 1968 to 1972.

Ramsay, Sir William (1852-1916), was a Scottish chemist who, with Baron Rayleigh, isolated the first rare atmospheric gas, argon. Ramsay also discovered the noble gases helium, neon, krypton, and xenon. He received the 1904 Nobel Prize for chemistry. His explanation of the nature of these elements led to important ideas about atomic structure. In addition, the gases have great practical importance. Each of these elements has a separate article in *World Book.*

Ramsay was born in Glasgow. He was knighted in 1902, and in 1911, he became president of the British Association for the Advancement of Science.

See also **Element, Chemical.**

Ramsden, Jesse (1735-1800), was a British mathematical-instrument maker and an inventor of optical instruments. His best-known work is an eyepiece for a microscope, called a *Ramsden eyepiece.* It can contain a wire grid for scale measuring. He also invented an instrument for measuring the expansion of metal bars and a mounting for astronomical telescopes. He was born at Salterhebble, near Halifax, in West Yorkshire, England.

Ramses II was the Egyptian *pharaoh* (king) who reigned from about 1290 to 1224 B.C. Ramses came to the throne at an early age. He served as *coregent* (coruler) with his father, Seti I, for a short time before he began his own long reign. During the early part of his reign, Ramses tried to end Hittite control of Syria. About 1285 B.C. he fought an indecisive battle against the Hit-

Statues of Ramses II guarded the Abu Simbel temple near the Nile for more than 3,000 years. Construction of the Aswan High Dam made it necessary to move the temple to higher ground.

tites at Kadesh and claimed a great victory. But about 1269 B.C., Ramses made a treaty with the Hittite king which divided Syria between them (see **Hittites**).

During the rest of his long reign, Ramses devoted his energies to a vast building programme. He built a new capital in the Nile Delta. He completed the *hypostyle* (columned) Great Hall of the Temple of Amon-Re at Karnak. He also built the mighty rock temples at Abu Simbel, and other temples in nearly every important Egyptian city. Ramses also took credit for many buildings of his ancestors.

Ramses was probably the pharaoh spoken of in the Biblical book of Exodus. The mummy of Ramses is preserved in the Egyptian Museum in Cairo.

See also **Cleopatra's Needles; Abu Simbel, Temples of.**

Ramsey, Lord (1904-1988), Baron Ramsey of Canterbury, was archbishop of Canterbury and primate of all England from 1961 to 1974. A Biblical scholar and theologian, he represented the *high church* or *Anglo-Catholic* wing of the Church of England. Ramsey considered a three-fold ministry of bishops, priests, and deacons essential to the church. He advocated unity among Christian churches and greater self-determination for the Church of England.

Arthur Michael Ramsey was born in Cambridge and educated at Cambridge University. He served as bishop of Durham and archbishop of York before he became archbishop of Canterbury. He became a peer in 1974.

Ramsey, Sir Alfred (1922-), managed the Football Association team that won the World Cup in 1966. He was manager to the England team from 1963 to 1974. He was born Alfred Ernest Ramsey in Dagenham, London, but called Alf. Ramsey played for Southampton and Tottenham Hotspur. He played for England 31 times. Then, as manager of Ipswich Town, he brought the club from the third division to the league championship. He was knighted in 1967.

Ramsgate is an English resort on the east coast of the Isle of Thanet in Kent. Ramsgate is a port, serving primarily for the importation and exportation of motorcars. It also has excellent sands and bathing facilities. Pegwell Bay, to the south of Ramsgate, has scheduled hovercraft services to Calais. See also **Kent** and **Thanet.**

Ramus. See **Mandible.**

Ranching usually means raising cattle and sheep on large farms. Some fruit farms and farms that raise such small fur animals as mink are also called *ranches.* This article deals with cattle and sheep ranching.

Cattle and sheep ranches are very large because it generally takes many acres of grassland to feed a herd. An average ranch in the Western United States, for example, covers nearly 1,356 hectares.

Most American ranches are found in the Western United States and Canada. Australia, Argentina, Mexico, New Zealand, and African countries also have ranches. But Australians and New Zealanders call them *stations.*

Most early ranchers in the United States raised cattle on unfenced land called *open range.* Workers called *cowboys* or *cowhands* rode herd on the cattle. Today, ranchers generally own much of the land in their ranch, and they and members of their family do most of the work. Neighbours help each other when extra help is needed. Only the largest ranches employ cowhands.

Life on a cattle ranch centres on raising calves that can be sold as *stocker cattle* or as *feeder cattle.* After the animals are fattened, they are called *slaughter cattle* and are shipped to a *stockyard* (market) where they are sold and slaughtered for meat. The rancher usually keeps some of the *heifer* (female) calves to replace older cows.

Ranchers start their year in the autumn after selling their calves. They prepare for winter by buying or harvesting a hay crop and such feed grains as barley, maize, oats, or sorghum.

Throughout the year, ranchers mend fences, repair machinery, and make sure the watering holes contain enough water for their cattle. They also put out blocks of salt mixed with other minerals that the cows can lick, because cattle need such minerals in their diet. In the autumn, neighbours help each other round up the cattle. Then the calves that are old enough to be *weaned* (taken from their mothers) are sold.

Ranch life once was lonely. But the car, truck, and good roads have brought the rancher closer to other people. Most ranch children ride school buses to school in nearby towns. Ranch families now live in comfortable homes that have electricity, modern plumbing, a telephone, and other modern conveniences.

Sheep stations. In Australia and New Zealand there are about 230 million sheep on about 120,000 stations. Australia has 16 per cent of the world's sheep and produces almost a third of the world's wool. New Zealand is the world's third largest producer and the second largest exporter of wool. The first sheep brought to Australia in 1788 were intended for meat rather than for wool. Today wool production is among the most important industries both in Australia and New Zealand.

Life on a sheep station is different from life on a cattle ranch because sheep produce two crops—lambs and wool. In the spring, crews of workers use power clippers to *shear* (cut off) the sheep's wool and the rancher sells it. Lambs are usually born in spring. They and the

freshly sheared *ewes* (mother sheep) are then branded with paint or are ear tagged. In the autumn, most of the lambs are weaned, shipped to feeders or stockyards, and sold for slaughter.

History. Cattle ranching in the United States began in the mid-1800's. The industry was established in the southern tip of Texas by Mexican ranchers. They developed equipment such as the lassoo, a rope with a *noose* (loop with running knot), and a specially designed saddle with a *pommel* (knob) at the front used when catching cattle. These articles were adopted, with modifications, by the Texas cowboy. The ranchers raised cattle on the open range, and hired cowhands to help guard and herd the cattle.

When the cattle were almost ready for slaughter, the ranchers formed big herds and drove them overland to the nearest railway station. A single herd had several thousand cattle and moved from 16 to 24 kilometres each day. Then the cattle were sold to buyers who shipped the cattle to the East.

During the 1870's and early 1880's, large ranches developed in the West. One, the XIT ranch in northern Texas, was 320 kilometres long, 40 kilometres wide, and had 150,000 cattle. Many cowhands worked on these big ranches, and they lived in buildings called *bunkhouses.* But in the mid-1880's, bad weather killed thousands of cattle, and ruined many ranchers. Many big ranches were sold and divided.

Range wars. Some of the best land was *homesteaded* (given to individuals who promised to live on it and farm it). Homesteaders built fences to protect their crops from cattle. Sheep ranching also began to develop. Sheep ranchers moved sheep from one range to another, and the sheep occasionally grazed on ranges that cattle used. Soon, cattle ranchers, homesteaders, and sheep ranchers began to fight for the land and watering holes. Many of these disputes developed into bloody *range wars.* Unlimited use of the open range ended in 1934. Since then, ranchers have needed permits to graze herds on federal land.

Damage caused by ranching. The conversion of tropical forests for cattle ranching in most Latin American countries has had serious environmental effects. Forest clearing for ranching in Latin America has taken almost 40 per cent of its original tropical forests, most of it in the past 35 years. The effect on the environment has caused such concern that some countries, such as the United States, have considered banning beef imports from tropical Latin America.

For a description of ranch life in the American Old West, see **Cowboy**. See also **Australia** (Agriculture); **Cattle; Sheep.**

Rand Corporation is a nonprofit research organization that studies various policy problems of the United States, especially those involving national defence. The U.S. Air Force started Project RAND (*R*esearch *AN*d *D*evelopment) in 1946 to conduct long-range studies of intercontinental warfare by forces other than ground armies. RAND became an independent corporation in 1948, but the military, particularly the Air Force, still finances most of its work.

The Rand Corporation investigates such subjects as the military and economic strength of the Soviet Union and China, and the air defences of the United States. It

Life on cattle ranches has changed greatly since they were founded in the 1800's in the American Southwest. Ranchers still use cow ponies occasionally to rope calves, *above left,* and do other work. But now some also use helicopters, *above right,* to check on herds in distant parts of the ranch.

also studies international terrorism, nuclear arms control, defence resource management, weapon design, uses of earth satellites, and military and political conditions throughout the world.

Since 1967, the corporation has increased its research on such nonmilitary problems as city transportation, criminal justice, educational management, water supplies, and housing. Most of its reports on military matters are secret and are given directly to the Air Force or the Department of Defense. The corporation also operates an Army research centre and a graduate programme in policy analysis. The headquarters of the corporation are in Santa Monica, California.

Randolph, Peyton. See **Continental Congress.**

Random sample. See **Statistics** (Sampling).

Raney nickel. See **Hydrogenation.**

Range. See **Cooker.**

Rangefinder is a device for measuring distances. The military uses rangefinders to determine the distance to a target. Rangefinders are also used in surveying and photography.

The basis of a military rangefinder is a long tube with eyepieces at the centre and an arrangement of lenses and prisms at each end. By adjusting the prisms, the operator can sight the target simultaneously from both ends of the tube. The difference in direction of the two lines of sight is called the *parallactic angle.* This angle will be large at short distances, and small at long distances. The parallactic angle is measured on a dial from which the range in metres can be read directly.

There are two principal types of rangefinders. The operator of a *coincidence* instrument looks through a single eyepiece and sees two distinct images of the target. By turning a knob, the operator can make these two images merge. When this happens, the distance can be read on the range dial. The operator of a *stereoscopic* instrument looks through a pair of eyepieces like binoculars, and sees a single image of the target. The operator also sees a marker that appears to be floating in space near the target. The operator moves a knob until the marker and the target appear to be at the same distance. Then the distance is read on the range dial.

Since World War I (1914-1918), rangefinders have been used in naval gunnery as a part of *director systems* which aim the guns automatically. During World War II (1939-1945), the army adopted director systems for anti-aircraft fire. But radar, which can measure ranges more accurately, largely replaced the rangefinder in World War II. Since the early 1970's many armies have equipped tanks and other large weapons with *laser rangefinders.* These instruments measure the time needed for a light pulse to travel to and from a target. Laser rangefinders work both during the day and at night. Some can measure the distance to a target up 20 kilometres away.

See also **Radar.**

Rangers are specialized infantry units of the U.S. Army. Rangers are given much tougher training than other infantrymen. The Rangers were organized in 1942, during World War II (1939-1945), under the leadership of Colonel William O. Darby. The first regiment of 2,000 men was formed in the United Kingdom. It consisted of volunteers from the American Commando School. About 9 out of 10 of the first regiment lost their lives opening up enemy defences before invasions.

A group called *Rogers' Rangers* fought alongside the British and American armies during the Seven Years' War of the 1750's. They developed the stealthy, daredevil tactics of the American Indian, which have since been associated with the name ranger.

See also **Commando.**

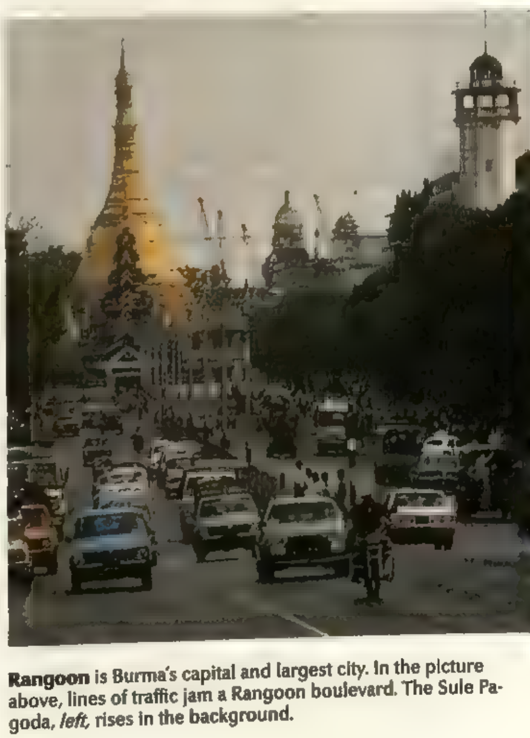
Rangers, Texas. See **Texas Rangers.**

Rangoon (pop. 1,315,964; met. area pop. 2,452,881) is the capital and largest city of Burma. It is also the country's chief port and industrial centre. In 1989, the Burmese government changed the name of the city from Rangoon to Yangon. Rangoon lies in southern Burma on both banks of the Rangoon River. It is about 32 kilometres north of the Gulf of Martaban, an arm of the Indian Ocean. For location, see **Burma** (map).

Rangoon has many Buddhist temples. The most famous is the 2,500-year-old Shwe Dagon pagoda in the centre of the city. Many buildings of the national government are in Rangoon. The city has a national museum and a number of parks and lakes. It is the home of the Rangoon Arts and Science University.

Many of Rangoon's people work for the government. The city's industries include shipbuilding, oil refining, and the milling of rice and wood. Rice and teakwood are Rangoon's principal exports, and the city ranks among the world's leading rice markets. Rangoon's factories manufacture pottery, and cloth made of cotton and silk.

In the A.D. 500's, a settlement called Dagon occupied the area that is now Rangoon. Dagon was a small town until the 1750's, when Alaungpaya, a Burmese king, founded the city and named it Rangoon. The British took control of Rangoon in 1824 and later of all Burma. The



Rangoon is Burma's capital and largest city. In the picture above, lines of traffic jam a Rangoon boulevard. The Sule Pagoda, *left,* rises in the background.

city remained under British rule during most of the period from 1824 until 1948, when Burma gained independence. Fire destroyed Rangoon in 1851, but the city was soon rebuilt. Rangoon's population has grown rapidly since Burma became an independent country.

Ranjit Singh (1780-1839), known as the *Lion of the Punjab,* was one of the most important figures in the history of India. He became the first Indian ruler to create a great Sikh kingdom (see **Sikhism**).

Ranjit was the son of an important chief in the Punjab, a region in northwest India. His father died when he was 12. At first, Ranjit ruled only a small state. But he gradually conquered neighbouring states and threw off the control of the powerful Afghans.

Ranjit wanted to unite all Sikhs in a great nation. He expanded to the north and west, and made his state the largest in the Indus valley. But the British prevented him from uniting all Sikhs. He signed treaties with the British that kept the peace.

Rank, Lord (1888-1972), Joseph Arthur Rank, was a major figure in the British film industry. The company that he developed, the J. Arthur Rank Organization, eventually had wide interests in dance halls, tenpin bowling, and photocopying machines.

Rank was born at Hull, in England. He entered the film industry to encourage the making of religious films. But his interests soon widened. The J. Arthur Rank Organization built up a large cinema circuit and made many feature films.

Ranke, Leopold von (1795-1886), a German historian, persuaded historians to use critical methods and examine history objectively. He introduced the seminar method of teaching. After 1840, his methods were largely used in teaching German historians. Ranke was born at Wiehe, in Thuringia. His first book, *History of the Romance and Teutonic Nations,* appeared in 1824. He also wrote *History of the Popes* and *History of the Reformation in Germany.* See also **History** (Modern times; picture).

Rankin, Dame Annabelle (1908-1986), a Liberal Party senator, in 1946 became the first Queensland woman to enter the Australian federal Parliament. She served as minister for housing from 1966 to 1971. As Australian high commissioner to New Zealand from 1971 to 1974, she was the first woman to head an Australian diplomatic mission. She was born in Brisbane.

Ransom. See **Kidnapping**.

Ransome, Arthur (1884-1967), was a British journalist and author best known for his series of children's books. His first book, *Swallows and Amazons* (1930), is a classic story about the Walker children and their camping and sailing adventures. It was followed by *Swallowdale* (1931) and several similar books. The last book in the series is *Great Northern?* (1947).

Ransome was born in Leeds and educated at Rugby and Yorkshire College in Leeds. He became a freelance writer of stories and articles at the age of 17. Ransome went to Russia in 1913. He taught himself Russian and stayed as a journalist until 1919. Ransome wrote books about Russia and fishing in addition to his books for children.

Ranunculus is the scientific name for about 250 species of perennial plants of the buttercup family. The plants have tuberous roots. Many species have white, yellow, or red flowers. The flowers are bowl-shaped and tend to flatten out as they open.

The colourful Ranunculus is a popular garden flower.

Ranunculus is also the common name of a particular species cultivated as a garden flower and as a cut flower. It has colourful, poppylike flowers that may be white, yellow, pink, orange, red, or maroon. It grows best in light soil enriched with organic matter and in a sunny, sheltered position.

Scientific classification. Ranunculus belong to the buttercup family, Ranunculaceae. The garden Ranunculus is a cultivated form of *Ranunculus asiaticus.*

See also **Buttercup**.

Rao, P. V. Narasimha, (1921-), became prime minister of India in 1991, after his Congress-I Party won the most seats in parliamentary elections. As prime minister, Rao has introduced economic reforms designed to encourage foreign investment and to increase economic development. His government has been hampered, however, by unresolved conflicts between the country's religious and ethnic groups.

P. V. Narasimha Rao

Rao, whose full name is Pamulaparti Venkata Narasimha Rao, was born in Karimnagar, near Warangal. He studied at Bombay and Nagpur universities. Rao became active in the Congress Party in the 1940's. In 1969, the party split into one group that supported Prime Minister Indira Gandhi and another that opposed her. Indira Gandhi's group became the Congress-I Party in 1978. Rao remained loyal to Gandhi and her son Rajiv, who succeeded her in 1984. In the 1980's, Rao held several cabinet positions, including foreign affairs minister, minister of defence, and minister of human resource development. In May 1991, the Congress-I Party chose Rao as its head after party leader Rajiv Gandhi was assassinated. Rao became prime minister in June.

See also **India, Government of.**

Rap music is a form of popular music that is generally spoken or chanted at a fast pace rather than sung. Rap is performed over musical accompaniment that emphasizes rhythm rather than melody. Often this accompaniment consists of short segments of earlier recorded music combined in new patterns.

Rap music first developed in the mid 1970's in New York City, and soon in other urban areas, primarily among African-American teenagers. The style soon spread throughout the United States and much of the world. Some critics believe that rap replaced rock music as the creative force in music of the 1980's and 1990's. However, the lyrics of some rap songs have caused controversy. Critics have charged that they promote racism and violence and show contempt for women.

The biggest inspiration for rap came from disc jockeys in Jamaica who would talk, or *toast,* over recorded music they played in clubs. The style, known as *dub,* produced popular records that featured disc jockeys talking over instrumental backing and electronic effects. A Jamaican-born disc jockey known as DJ Kool Herc is often credited with introducing rap into New York City. He and other disc jockeys used records playing on two turntables, switching rapidly from one to the other to mix and match beats between two songs.

Popular rappers have included Public Enemy, Hammer, Ice-T, Run-DMC, and Arrested Development.

See also **Rock music** (New directions and old).

Rapanui. See **Easter Island**.

Rape was an administrative region in Sussex, England, dating from Saxon times. The origin of the term is unknown. Sussex was divided into five rapes, called Arundel, Bramber, Hastings, Lewes, and Pevensey. Their boundaries ran from north to south, and each rape had its own port or navigable river. The city of Chichester later became the centre of a sixth rape.

Rape is the crime of forcing sexual intercourse upon a person against the individual's will. Women or men may be the victims of rape. This article discusses the rape of women. Rape is a serious crime, normally punishable by a term of imprisonment.

The number of rapes reported to the police increased dramatically in many countries during the 1980's. However, officials estimate that the actual number of rapes committed may be 10 times the number reported. Many rape victims do not report the crime to the police because of shame or fear. Some victims dread the possible humiliation of newspaper publicity or being asked embarrassing questions by the police or, later, in a courtroom. Also, many rapists threaten to kill their victims if the women go to the police.

Only a small percentage of all rapists are convicted and imprisoned. The low conviction rate results from the difficulty of proving rape in law. In some countries, courts require evidence from witnesses or evidence of bodily injury to the woman. Some courts also require proof that a woman struggled to resist her attacker. In most countries, the law demands evidence from a doctor proving that a woman has had recent sexual intercourse. For such proof, a woman must be examined within 24 hours after the rape. In some cases, a defence lawyer may try to cast doubt on a woman's story by asking about her past sex life. The jury may conclude that a woman has low morals and willingly consented to sexual intercourse if she had sexual experiences with several men in the past.

Some countries have changed their laws on rape. They have eliminated laws that require evidence from witnesses or evidence of bodily injury. Some have limited the introduction of information on a woman's previous sexual experience and ban reporting of rape victims names or any other information that will indentify them. In addition, some local communities have trained a number of policewomen to deal with rape victims. Many women find it easier to discuss such an experience with another woman than with a man.

During the 1970's, many women banded together to form *rape crisis centres.* These centres offer counselling for rape victims, most of whom feel great anxiety and depression after being attacked. The rape crisis centres also encourage women to report the crime to the police. In addition, various groups and educational institutions offer instruction on rape prevention.

Many psychologists believe that few men commit rape for sexual pleasure and that rape is an antisocial act which is only incidentally sexual. According to some, many rapists fear and hate women and want to prove their domination by humiliating and hurting them.

Rape is a flowering herb of the mustard family. It is grown commercially in Asia, Canada, Europe, New Zealand, and the United States. Some varieties of rape are called *rutabagas* in the United States and *swedes* in Europe. They have an edible turniplike root. Farmers grow other varieties of rape as pasture crops. Varieties called *rapeseed* are grown for their oilbearing seeds, which are processed into livestock feed, vegetable oil, and industrial lubricants.

Canola is a variety of rapeseed from which canola oil is obtained. Food processing companies use canola oil to make cooking oil and such products as margarine and salad dressings. Canola oil is popular because it is lowest in *saturated fat* among vegetable oils. Saturated fats seem to increase the amount of *cholesterol* in blood and may contribute to heart disease (see **Cholesterol**).

The rape plant grows from about 60 to 180 centimetres tall. It has slender, branched stems with bluish-green leaves. The plant bears pale yellow flowers that are about 1.5 centimetres long.

Some varieties of the plant live only one year. Others live for two years.

Scientific classification. Rape plants are members of the mustard family, Brassicaceae or Cruciferae. All varieties belong to either of two species, *Brassica napus* and *B. campestris.*

The rape plant

Oil painting on wood panel (1504); Brera Gallery, Milan, Italy

Raphael's *Marriage of the Virgin* is one of his earliest masterpieces. It shows Perugino's influence in the work's sentimental quality. This painting is particularly noted for its graceful, relaxed figures and expert use of perspective.

Raphael (1483-1520), was one of the greatest and most influential painters of the Italian Renaissance. His graceful figures and skilful compositions influenced artists up to the early 1900's. The period of his activity is still called the *High Renaissance.*

Raphael painted altarpieces, *frescoes* (wallpaintings) of historical and mythological scenes, and portraits. His most popular works include his many gentle paintings of the *Madonna* (Virgin Mary). Raphael was also an architect. From 1514 until his death, he directed the construction of St. Peter's Church in Rome.

His life. Raphael was born in Urbino. His real name was Raffaello Sanzio. His father served as court painter to the Duke of Urbino. About 1494, Raphael's father sent the boy to Perugia to study with Perugino, an important painter. Perugino introduced Raphael to the latest ideas in Italian art and greatly influenced his student's style.

Raphael settled in Florence in 1504. There he studied the paintings of the great Italian artist Leonardo da Vinci. Leonardo painted beautiful figures that looked more like ancient Roman gods and goddesses than ordinary people. His balanced compositions and idealized figures had a strong influence on all Renaissance painters, including Raphael.

Late in 1508, Pope Julius II asked Raphael to work for him in Rome. Julius wanted to rebuild and redecorate Rome to reflect its ancient glory. He gathered together the most illustrious architects, painters, and sculptors from all parts of Italy. Raphael created his finest work while in the service of Julius and his successor, Pope Leo X. Raphael worked in Rome until he died, after a short illness, at the age of only 37.

His works. A masterpiece of Raphael's early career is the *Marriage of the Virgin* (1504), reproduced on the left. The painting shows the influence of Perugino's somewhat sentimental style. However, Raphael's own style can be seen in the dignified figures and the emphasis

Fresco (1510-1511); The Vatican, Rome

Raphael's *School of Athens* shows a gathering of leading ancient Greek philosophers and scientists. Plato and Aristotle stand in the centre under the arches, and Diogenes is the old man reclining on the steps. Scholars believe the man writing on a stone block in the foreground is the great Renaissance artist Michelangelo.

on perspective. The painting shows a gentle and graceful Virgin Mary receiving a ring from an ideally handsome Joseph.

Perhaps Raphael's greatest achievement was the series of frescoes that decorate the pope's private quarters in the Vatican. Raphael painted several of these frescoes in a room called the Stanza della Segnatura. Each wall in the room has an arch to support the curved ceiling. Raphael brilliantly incorporated this architectural feature into his compositions.

Raphael's *School of Athens,* shown on the previous page, covers one wall of the Stanza. He used the actual arch in the wall to frame the painting. Three painted arches serve as a background for the ancient Greek philosophers and scientists in the front of the scene. In the centre, beneath the arches, stand Plato and Aristotle, the leading philosophers. A detail of these two figures appears in the *World Book* article on **Plato.** Raphael grouped the main representatives of the schools of Greek philosophy and science in casual but carefully organized arrangements. The scene expresses the sense of clarity, space, and proportion for which Raphael became famous.

For other examples of Raphael's work, see the pictures with the articles on **Painting; Ark of the Covenant;** and **Renaissance.**

See also **Painting** (The later Renaissance).

Rapid Deployment Force is a United States military force designed to move quickly to protect U.S. interests anywhere in the world. This force, commonly called the RDF, consists of land, air, and sea units drawn from the Army, Air Force, Marine Corps, and Navy. The units are assembled only when needed, and the size and composition of the RDF vary according to the requirements of a situation. The official name of the RDF is the Rapid Deployment Joint Task Force.

Rapids. See **Waterfall.**

Rapparees were Irish marauders in the unsettled southern counties of the country in the late 1600's. Many began lives of banditry as political outlaws during the Williamite wars. These wars took place following the Glorious Revolution of 1688 and the accession of William and Mary to the English throne. Some of the rapparees stole to survive. Others attacked only their Protestant opponents. Still others would attack anyone—Protestant or Catholic, English or Irish—with something worth taking.

Rare earth is any one of a group of metallic elements with atomic numbers 58 to 71. The German chemist Carl Gustav Mosander was the first to study the rare earths in the 1840's. The name *rare earth* is really incorrect, since they are neither rare nor earths. They received this name because chemists first isolated them in their oxide forms. These oxides somewhat resemble calcium, magnesium, and aluminium oxides, sometimes called *common earths.*

Rare earths have three electrons in the outer shells of their atoms that take part in valency bonding. Because of this structure, all rare earths have similar properties in water solutions, and all can exist in the *trivalent* (three electric charges per atom) state. Because of their similar chemical properties, they are difficult to separate. The elements scandium, yttrium, lanthanum, and actinium also have three valency electrons. They are sometimes called rare-earth elements, but they have somewhat different electronic structures.

The rare earths

Element	Chemical symbol	Atomic number	Atomic weight
Cerium	Ce	58	140.12
Praseodymium	Pr	59	140.907
Neodymium	Nd	60	144.24
Promethium	Pm	61	145.00
Samarium	Sm	62	150.35
Europium	Eu	63	151.96
Gadolinium	Gd	64	157.25
Terbium	Tb	65	158.924
Dysprosium	Dy	66	162.50
Holmium	Ho	67	164.930
Erbium	Er	68	167.26
Thulium	Tm	69	168.934
Ytterbium	Yb	70	173.04
Lutetium	Lu	71	174.97

Each element listed in this table has a separate article in *The World Book Encyclopedia.*

The rare-earth elements are also called the *lanthanides* because they follow lanthanum in the periodic chart of elements. The elements following actinium are called the *actinides.*

The true rare earths are silver-coloured metals. In nature, they are always found together in combination with nonmetallic elements in the form of phosphates, carbonates, fluorides, silicates, and tantalates. The minerals monazite and bastnasite are the chief sources of the rare earths. The rare earths are not really rare. Even the scarce rare earths, such as europium and lutetium, are more common than the platinum-group metals. Promethium does not occur naturally, but forms as a result of atomic reactions. Many rare earths form during the fission of uranium and plutonium (see **Fission**).

The rare earths have many scientific and industrial uses. Separated rare earths are used in lamps, lasers, magnets, phosphors, and X-ray intensifying screens. The material that gives off red light in a colour-television screen consists of yttrium or gadolinium oxide or oxisulphate that is activated with europeum. Cerium is used for decolorizing glass. Cerium and niobium are also used for colouring of glass, praseodymium oxide is used to stain ceramics yellow. Unseparated rare earths are added to various metals, including aluminium and magnesium, to make them stronger. The carbon electrodes used in film projectors have rare-earth cores. A mixed rare-earth alloy called *misch metal* is combined with iron to make flints for cigarette lighters. Rare-earth compounds are widely used as catalysts in the production of various petroleum and synthetic products.

Until 1945, processors had to use long and complicated chemical processes to obtain significant amounts of pure rare earths. This made them scarce and costly. Today, *ion-exchange* and *solvent extraction* processes have made possible a rapid separation that gives highly pure, low-cost rare earths.

See also **Berzelius, Jöns Jakob; Element, Chemical** (tables); **Scandium; Yttrium.**

Ras Tafari. See **Rastafarians; Haile Selassie I.**

Rasp, Charles (1846-1907), discovered silver deposits near Broken Hill, in New South Wales, Australia, in 1883, while working as a boundary rider. A settlement grew up around the deposits. In 1884, prospectors discov-

ered lead ores. In 1885, Rasp and some farmers of the district formed the Broken Hill Proprietary Company Ltd. to exploit the ores. Rasp was born in Germany. He migrated to Australia in 1869.

Raspberry is a thorny bush that produces small, round, tasty fruit. Each fruit, also called a *berry,* consists of a cluster of cells, called *drupelets,* that look like tiny beads. Drupelets are partly hard and partly fleshy and grow around a core known as a *receptacle.* The receptacle remains on the bush after the fruit is picked. Most commercially grown raspberries such as the *European raspberry,* are red, but some are purple, white, or yellow. Raspberries are eaten fresh or used to make jams and jellies. Frozen raspberries are also popular. Occasionally people use raspberry leaves to make tea.

Raspberries grow best in cool regions. Before its breakup, the Soviet Union produced more raspberries than any other country. Poland ranked second. Other species of raspberries include the *yellow Himalayan raspberry* of India, and the *wine raspberry* of Japan.

Growing raspberries. Growers begin new red raspberry bushes from raspberry *suckers* obtained from healthy plants. Suckers are underground shoots that grow from the roots of the plants. The suckers are raised in a nursery for one growing season and then transplanted outdoors in the autumn. During the first growing season after they have been transplanted, the suckers produce only *canes* (stems) and branches. Fruit and flowers develop the following year.

Growers produce new black and purple raspberries by bending the tips of raspberry plants over and covering them with soil. The tips develop roots, which are transplanted the next season. The plants do not produce fruit until the second growing season after the roots have been transplanted.

Most raspberry plants produce fruit for about six years. The bushes thrive in deep, fertile, well-drained soil. It is important to keep the plants well watered, especially when the fruits are ripening.

Raspberries are commonly grown in rows. The plants can be supported by wire strung between stout posts, a little over 2 metres high. The canes should be planted about 35 centimetres apart depending on the variety of raspberry planted.

Raspberries are tasty fruits that grow on thorny bushes. Each berry consists of a cluster of tiny, beadlike *drupelets.* Most raspberries are red, but some are purple or black.

Pests and diseases. Raspberries are attacked by a number of insect pests, and bacterial and fungal diseases.

Insect pests include aphids that feed on the new shoots and transmit viruses. The larvae of the raspberry beetle bores into the fruit making them inedible.

Fungal diseases include grey mould that rots the berries, and cane spot that causes white circular patches on the leaves. Viral diseases cause a mottling and blotching of the leaves.

Scientific classification. The raspberry belongs to the rose family Rosaceae. The European raspberry is *Rubus idaeus,* the American black raspberry is *R. occidentalis,* the yellow Himalayan raspberry is *R. ellipticus,* and the wine raspberry is *R. phoenicolasius.*

Raspe, Rudolph Erich. See Munchausen, Baron.

Rasputin, Grigori Efimovich (1872?-1916), a Siberian peasant, gained the reputation of a saint and exerted harmful influence on Nicholas II, the last Russian czar, or emperor. He contributed to the downfall of the Russian Empire. See **Russia** (History [The February Revolution]).

Rasputin was born in western Siberia. He joined a religious sect while in his thirties. Rasputin went to St. Petersburg, then the capital of Russia. In 1907, he was introduced to the czar and czarina in order to help heal their son, who suffered from haemophilia. Rasputin's apparent success gave him great influence on the imperial couple, and he began to meddle in political decisions and ministerial appointments.

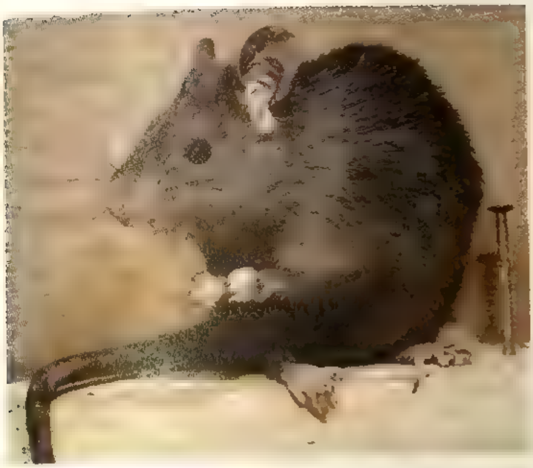
Grigori Rasputin

Rasputin had common sense, but he was selfish, greedy, and dissolute. A group of high nobles feared that widespread hatred of Rasputin would turn against the czar himself. They assassinated Rasputin in December 1916. But they did not save the empire. Revolution broke out within three months.

Rastafarians are members of Ras Tafari, a religious and political movement that began in the Caribbean island of Jamaica in the 1920's. Members now live on other Caribbean islands as well as in many cities in other parts of the world. *Ras Tafari* was a common name of former Emperor Haile Selassie I of Ethiopia, and Rastafarians consider Selassie as a god. Selassie held power in Ethiopia, a country in northeastern Africa, from 1916 to 1974.

Rastafarians estimate their numbers in the hundreds of thousands. They are probably best known for their popular style of music, known as *reggae.* In addition, many Rastafarians wear their hair in long, ropelike braids called *dreadlocks.*

Ras Tafari is primarily a black movement. The main traditional Rastafarian beliefs hold that (1) white people



Rats are small, furry mammals that have plagued human beings for centuries. The black rat, *above,* causes disease and widespread property damage to houses and factories.

are wicked and inferior to blacks, (2) Ethiopia is heaven, and (3) Haile Selassie would arrange for the return of all African descendants to Africa. However, the death of Selassie in 1975 has raised questions among Rastafarians concerning the traditional beliefs. Today, there is less emphasis on Ethiopia and more on Africa as a whole. Some members have also changed their beliefs about whites. In some Rastafarian groups in Jamaica, anyone who believes in Selassie as a god is welcomed into the religion regardless of race or colour.

See also Jamaica (People); **Haile Selassie I.**

Rastatt, Treaty of. See **Succession Wars.**

Rat is a furry mammal that looks like a mouse but is larger. The smallest kinds of rats grow longer and weigh more than the largest mice. Rats, like mice, beavers, and squirrels, are *rodents.* All such animals have chisellike front teeth especially suited for gnawing.

There are about 120 kinds of rats, of which the best known are the *black rat* and the *brown rat.* Both these species live in all parts of the world. The *Nile rat* is a pest in North and East Africa. Most other kinds of rats live in areas not inhabited by people.

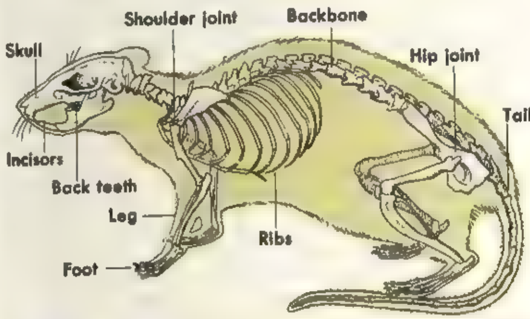
Black rats and brown rats rank among the most serious animal threats to people. They carry the germs of several diseases, including bubonic plague, food poisoning, and typhus. Rats also damage or destroy crops and other food products, and they kill poultry, lambs, and baby pigs. On the other hand, scientists use rats in research projects that have benefited people.

The word *rat* is often used for any long-tailed rodent that is larger than a mouse. But most of these animals are not true rats. They include the cotton rat, the rice rat, the kangaroo rat, and the wood rat.

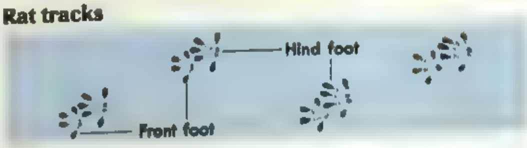
The body of a rat. All species of rat have a slender, scaly tail and long, sharp claws. But black rats and brown rats differ in several ways besides colour.

Black rats grow to 18 or 20 centimetres long, excluding their tail, and weigh about 280 grams. The tail is longer than the rest of the body. These rats have large ears, a pointed snout, and soft fur. The fur of a black rat may be black, greyish-brown, or smoky-grey. Grey, white, or yellow fur covers the animal's underside. Black rats are also called *roof rats* or *ship rats.*

The skeleton of a rat



Rat tracks



Brown rats measure from 20 to 25 centimetres long, not including their tail, and weigh up to 485 grams. The tail is shorter than the rest of the body. Brown rats have small ears, a blunt snout, and coarse fur. They vary in colour from brownish-grey to reddish-grey. Other names for the brown rat include *barn rat, grey rat, house rat, Norway rat,* and *sewer rat.*

The life of a rat. Black rats and brown rats originally lived only in Asia. They reached Europe either by ship or overland. From western Europe, the animals spread to North and South America on ships.

Both black and brown rats live in large groups, with certain rats *dominating* (having control over) others. Most members of each species build a nest in or near buildings. Black rats live in the upper storeys of buildings or in trees. Brown rats are found under floors,

Newborn rats, such as these brown rats, cannot see or hear. They remain in the nest with their mother for about three weeks. Brown rats have eight or nine babies in each litter.

White rats play an important role in scientific research. In the picture above, a drug company researcher measures weight changes in a rat that has been given an experimental medicine.

within walls, in piles of refuse, or in the ground. If the two species live in the same building, black rats usually occupy the upper levels, and brown rats dwell on the ground level. Rats are cautious creatures and generally avoid anything unfamiliar in their environment. They have a keen sense of smell and can quickly detect approaching danger.

Both black and brown rats eat almost any kind of plant or animal—even other rats of the same or a different species. The brown rat is fierce and aggressive, compared with the milder black rat. Rats feed mostly at night, and sometimes they band together and attack such animals as chickens and pigs. Most rats live within an area that may be no more than 45 metres in diameter. But if a food shortage occurs, rats may travel long distances in search of food.

Most black and brown rats mate the year around, and the females give birth to three to six litters annually. A female rat carries her young in her body for about three weeks before they are born. Most black rat litters consist of six or seven babies. Most brown rat litters have eight or nine. Newborn rats are blind and deaf. They remain in the nest for about three weeks.

Few rats live more than a year in their natural surroundings because they have so many enemies. Animals that prey on rats include cats, dogs, hawks, owls, snakes, and weasels. In captivity, some rats live more than three years.

Rats and people. Both black and brown rats destroy eggs, fruit, stored grain, vegetables, and other foods and attack various farm animals. Rats also cause considerable additional damage by gnawing on such objects as furniture and lead pipes. They sometimes cause fires by chewing the insulation off electric wires. In addition to spreading disease, rats sometimes attack human beings, including babies in cots. Their bite may cause rat-bite fever.

Some people fight rats by destroying the food sources or homes of the animals. Others kill rats by poisoning, shooting, or trapping them. Rat poisons must be used carefully to prevent accidental poisoning of human beings or of other animals.

Rats may also be controlled by placing specially treated food in areas where they live. Such food contains chemicals called *antifertility drugs.* These drugs make the rats incapable of reproducing.

Domesticated varieties of brown rats, especially the *white rat,* play an important role in many scientific experiments and research projects. Researchers use white rats in studies of disease, drug effects, heredity, nutrition, and learning and other aspects of behaviour. They also use rats in the preparation and testing of new drugs. Many zoos maintain colonies of rats as food for snakes and other animals. Some people keep domesticated rats as pets.

Scientific classification. Rats belong to the family, Muridae. Black rats are *Rattus rattus,* brown rats are *R. norvegicus* and the Nile rat is *Arvicanthis niloticus.*

See also **Mouse; Rodent; Kangaroo rat; Wood rat.**

Rata vine grows in New Zealand forests. Most species are stout climbers with stems up to 13.5 centimetres in diameter. Bushmen quench their thirst by drinking the juice that oozes from the cut stems. Small rata vines are straggling climbers with ragged bark and small pink or white flowers. Southern rata, or *ironwood*, grows 12 to 18 metres as a tree and has large, fluffy, scarlet flowers.

Scientific classification. Rata vines belong to the myrtle family Myrtaceae and the genus *Metrosideros.* The southern rata is *M. umbellata.*

Ratana is a Maori religious and political movement in New Zealand. About 40,000 people belong to it. It is named after its founder, Tahupotiki Wiremu Ratana (1873-1939). The movement grew up at a time when the Maori and their culture seemed likely to die out, helpless to resist European diseases and social change. The movement gave new life to Maori culture.

Ratchet is a wheel or bar that can move in only one direction. It often consists of a notched wheel and a *pawl* (metal bar hung from a pivot). The pawl is attached to a lever. As the lever is moved, the free end of the pawl locks into a tooth of the wheel, causing the wheel to rotate. A second pawl may be used to prevent the wheel from turning backward while the lever is being returned to begin another stroke.

A mechanical counter is a simple device that uses the ratchet-and-pawl combination. A ratchet-and-pawl mechanism locks a machine such as a hoisting winch so that it does not slip.

Rate of exchange. See **Exchange rate.**

Ratel is a badgerlike animal that lives in Saudi Arabia, India, Nepal, and much of Africa. It is also called *honey badger* because it often feeds on honey. The ratel is about 75 centimetres long. It has white or dark-grey fur on its upper body and black fur on its underside. Ratels have long claws and their thick, loose skin protects them from stings or bites. They also have special glands that give off a foul-smelling liquid that discourages their enemies. These weapons help make the ratel a fearless fighter.

Ratels live in holes in the ground, among rocks, or in hollow logs, stumps, or trees. They may travel alone or in pairs. Ratels feed chiefly on honey, insects, small mammals, lizards, and both poisonous and nonpoisonous snakes. They also eat plants, roots, and fruit. The ratel often looks for honey with the help of a bird called the *honey guide.* The honey guide's call leads the ratel

The ratel, unlike most fur-bearing mammals, is light on top and dark below, reversing the usual coloration.

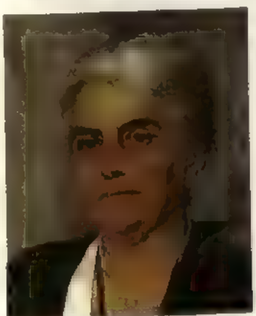
to a beehive. The ratel then breaks open the hive with its claws, and both animals feed.

Scientific classification. The ratel belongs to the weasel family, Mustelidae. It is classified as *Mellivora capensis.*

Rates. See Property tax.

Rathbone, Eleanor Florence (1872-1946), was a British social reformer. Her deep concern for all forms of human suffering gave urgency to her work. She was concerned with such varied problems as the treatment of widows under the Poor Law and the general welfare of women in the Commonwealth, particularly in India.

Eleanor Rathbone was born in London and educated at Oxford University. She undertook social work in Liverpool and became concerned about the plight of women. She campaigned to give women the vote, becoming parliamentary secretary to the Liverpool Women's Suffrage Society in 1897. She was an independent member of Parliament from 1929 to 1946 and fought for the introduction of family allowances. During World War I, she worked tirelessly for refugees.



National Portrait Gallery, London

Eleanor Rathbone

Ratio is an ordered pair or set that represents a relationship between numbers or quantities. The numbers in a ratio are called the *terms* of the ratio.

The ratio of two numbers or quantities represented by the letters *a* and *b* may be written as *a:b, (a,b), a/b,* or $\frac{a}{b}$. All fractions and percentages are ratios. The expression "40 per cent" may be restated as $\frac{40}{100}$ or 40:100. Two ratios are equal when each term of one ratio can be multiplied by a certain number to produce the terms of the other ratio. The expressions 2:3, 4:6, and 6:9 represent equal ratios. Two equal ratios make up a *proportion* (see **Proportion**).

Ratios may be used to describe a variety of relationships. For example, a ratio may express the relationship between the amounts of two ingredients in a liquid mixture. If a mixture contains 5 litres of syrup and 15 litres of water, the relationship, or ratio, of syrup to water is 5:15 or 1:3. A ratio may also indicate the rate at which something occurs, such as the use of petrol by an car. The rate of petrol-use for a car that travels 30 kilometres on a litre of petrol is expressed by the ratio 30:1. Such a ratio may also be stated as "30 kilometres per litre." A ratio may also describe the probability of the occurrence of an event. For example, the probability of drawing an ace from a well-shuffled deck of cards is described by the ratio 4:52 or 1:13. The terms of this ratio are derived from the number of aces (4) and the total number of cards (52) in the deck.

Ratio ranks as one of the most widely used mathematical concepts. It plays an important role in many fields. In physics, for example, ratio provides a basis for the concepts of speed and acceleration.

See also **Fraction; Percentage; Trigonometry.**

Rational number is any number that can be expressed in the form $\frac{a}{b}$, where *a* is any integer and *b* is any integer except zero. Integers are whole numbers greater than, less than, or equal to zero. Rational numbers include such positive numbers as $\frac{1}{4}$ and $\frac{3}{5}$ and such negative numbers as $-\frac{1}{3}$ and $-\frac{5}{8}$.

Integers are rational numbers because they can be expressed as fractions ($\frac{a}{b}$). For example, the integers 3 and -5 can be written as the fractions $\frac{3}{1}$ and $-\frac{5}{1}$. *Terminating decimals* and *repeating decimals* are also rational numbers. Terminating decimals are decimals that have a limited number of digits. For instance, 0.75 is a terminating decimal. When expressed in the form $\frac{a}{b}$, 0.75 becomes $\frac{3}{4}$. Repeating decimals repeat the same digit or a series of digits. In the repeating decimal $0.\overline{6}$, the digit 6 repeats indefinitely. When expressed in the form $\frac{a}{b}$, $0.\overline{6}$ becomes the fraction $\frac{2}{3}$.

Numbers that cannot be expressed as $\frac{a}{b}$ are called *irrational numbers. Pi* (π), for example, can be written as a decimal with an approximate value of 3.14159. However, the decimal continues indefinitely, does not repeat, and cannot be converted into a fraction. Pi is therefore an irrational number. See also **Pi.**

Rationalism is an outlook that emphasizes human reason and its ability to answer basic questions. *Philosophical rationalism*, in the 1600's, stressed the power of reason as opposed to sense experience. René Descartes, Gottfried Leibniz, and Baruch Spinoza developed philosophical systems based on the idea that, through reason, people have direct access to the nature of reality. *Cultural rationalism*, in the 1700's, relied on reason rather than on faith in creating a theory of human beings and their destiny. Voltaire and Thomas Paine were prominent figures in this movement. See also **Age of Reason; Philosophy** (Modern philosophy).

Rationing is a system used by a government to distribute scarce products among the people of a country. Rationing is generally used only during a war or some other emergency. During a war, for example, many people may be engaged in producing goods to help the war effort. Output of normal goods will be cut back because of a lack of manpower and financial resources. Thus, manufacturers cannot produce enough of these products to satisfy the people's demand.

When people want to buy more products than manufacturers can supply, *inflation,* a period of rising prices, usually results. A government can try to fight inflation by using a system of *price controls* to limit the amount of money that manufacturers can charge for their products. Through rationing, the government also tries to assure a fair distribution of the scarce products to all the people.

The two most common types of rationing are *specific rationing* and *point rationing.* Specific rationing uses a coupon for each type of rationed product. The government gives each household a certain number of coupons for the rationed goods. A person must submit the correct coupon and the cash value of each rationed item being purchased. Specific rationing generally is used to control the sale of scarce products that vary little in value and quality, such as petrol and sugar. To use this rationing system for such goods as meat and clothing, which differ greatly in value and quality, there would have to be coupons for every variety of the products. For such products, the government uses point rationing, giving each rationed item a point value. The government also gives each individual or family a certain number of points to use when buying products.

The stages involved in creating an effective ration programme may be difficult to carry out. A large government organization must be set up to decide which products will be rationed and what price controls will be put into effect. Also, laws must be established and enforced to prohibit *black marketing,* the selling of rationed products without proper coupons or points. Black markets operate because people want to buy larger amounts of certain products than the government allows and are willing to pay a high price for them.

During World War II (1939-1945), many countries involved in the war rationed a wide variety of products, including cars, coffee, sugar, and tyres. Today, periods of rationing are common for certain items that are in short supply in a number of developing nations, including India and Sri Lanka. Rationing of essential goods including food, is quite common in Communist countries. This is because they are unable to produce enough goods or lack the foreign exchange to import them.

See also **Black market; Price control; World War II** (On the home front).

Rats of Tobruk were the Allied soldiers of World War II who withstood a siege of eight months during the 1941 North Africa campaign. The Allied forces were besieged by the German Afrika Corps in Tobruk, on the Libyan coast, after the rest of the British Army retreated. They held out from April 11 until December 10, when the Germans abandoned the siege. The Allied forces included British, Polish, and Australian troops, totalling 31,000. The Australian troops were part of the 9th Australian Division led by Major General L. J. Morshead. They were relieved by other Allied troops on October 22, having defended the perimeter against tank attacks. In the 9th Division, 3,000 men were killed and 941 were taken prisoner. The name "rats of Tobruk" was used sarcastically by the German propagandist Lord Haw Haw, but it was adopted proudly by the Australian troops.

Rattan is a tough, stringy material. It comes from the reedy stems of different kinds of palms that grow in East India and Africa. These trees belong to the genus of palms known as *Calamus.* The stems of rattan palms may grow to lengths of more than 150 metres. The plants climb over other trees by means of little hooks on the leaves.

In the countries where these palms grow, natives use the rattan stem to make ropes and mats. American and European countries import the stems. Manufacturers use them to make umbrella handles, walking sticks, furniture, baskets, ship cables, and chair bottoms. Rattan is strong, bends easily, and lasts long. The finest grades of rattan come from the island of Borneo. Other good rattans grow in Burma, Malaysia, Sri Lanka, and Sumatra.

Workers prepare the stems for shipment by cutting them into lengths of 1.5 to 6 metres. They remove the leaves and outer covering by pulling the stems through a notch in a tree or board. Some rattan palms have a fruit that can be eaten. The young shoots are eaten like vegetables.

See also **Basket making.**

Rattigan, Sir Terence (1911-1977), was a popular British dramatist. He became known in 1936 with his comedy *French Without Tears.* He followed it with a series of successes. His plays, in conventional form, include *Flare Path* (1942), *Love in Idleness* (1944), *The Winslow Boy* (1946), *The Browning Version* (1948), *Adventure Story* (1949), *The Deep Blue Sea* (1952), *Separate Tables* (1954), *Variations on a Theme* (1958), *Ross* (1960), *Man and Boy* (1963), *A Bequest to the Nation* (1970), and *Cause Célèbre* (1977). He also wrote television plays and film scripts, including film versions of his own plays. He was born in London and named Terence Mervyn Rattigan. He was educated at Harrow and Trinity College, Oxford. He was knighted in 1971.

Sir Terence Rattigan

Rattlesnake is any one of the poisonous snakes of the Western Hemisphere with a rattle on the end of the tail. The rattle is used to warn enemies to stay away, though rattlesnakes sometimes give no warning sound with the rattle before they bite.

The rattlesnakes are classed among the pit vipers. There are about 30 species of rattlesnakes. They live from southern Canada to Argentina. By far the greatest number of rattlesnakes live in the dry region of the southwestern United States and northern Mexico. One species is found over a large part of South America.

It is easy to recognize a rattlesnake by its rattle, which is a set of horny pieces loosely joined together. It makes a buzzing sound when the snake shakes it. Many other snakes also have the habit of vibrating the tail. Certain harmless snakes, often mistaken for rattlesnakes, can make a sound with their tails in dry grass or leaves. But a careful observer can quickly tell whether a snake is a real rattler. The rattlesnake always lifts its tail when it sounds. The harmless snake moves its tail back and forth on top of dry leaves or grass.

There are large and small kinds of rattlesnakes. The diamondback rattler of the southeastern United States is the heaviest of all poisonous snakes, though not the longest. It gets its name because diamond-shaped blotches edged with yellow cover its body. Diamondbacks rarely grow over 2 metres long. A few other rattlers grow almost as large. Several small kinds of rattlers ordinarily grow only 60 centimetres long. The horned rattlesnake, or sidewinder, found in desert regions, be-

longs to this group. The ridge-nosed rattlesnake and the pygmy rattlesnake are even shorter.

Females of the eastern diamondback, the timber rattlesnake, and the northern Pacific rattlesnake have young when they are 3 years old. The females then give birth every two to three years. The young are born in late summer. All rattlesnakes bear live young instead of laying eggs. The newborn snakes can take full care of themselves and give painful bites.

Naturalists know very little about the life span of rattlesnakes. Many people falsely believe that they can tell the age of a rattler by the number of segments, or "rattles," in its rattle. Two to four new segments are added each year, one every time the skin is shed. But when about 10 segments accumulate on the end of a rattlesnake's tail, they begin to fall off. The segments look like hollow rings, each one partly fitting over the one behind it. A young snake has a single small segment. Each new rattle is a little larger. Segments that develop on a full-grown snake are all about the same size.

Some common varieties of rattlesnakes

Most rattlesnakes eat birds and small mammals. A few also eat amphibians and reptiles. They destroy rodents and other animals that are harmful to crops.

The larger rattlers rank among the most dangerous of snakes. They should be carefully avoided. They do not always rattle before striking.

The rattlesnake sends out poison through two long hollow teeth, or fangs, in its upper jaw. The poison forms in a pair of glands behind each eye on the upper jaw. The rattlesnake's fangs are folded back in the mouth when not in use. When an angry rattlesnake strikes, the fangs are erected and the mouth opened wide.

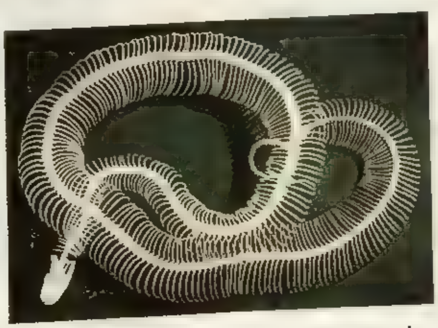
Scientific classification. Rattlesnakes belong to the viper family, Viperidae. The pygmy rattlesnake is *Sistrurus miliarius.* The ridge-nosed is *Crotalus willardi.* The eastern diamondback is *C. adamanteus;* the sidewinder is *C. cerastes;* the northern Pacific is *C. viridis oreganus;* and the timber is *C. horriduas.*

See also Snake; Snakebite.

Rattner, Abraham (1895-1978), was an American painter who is best known for his religious works. His paintings are noted for their brilliant colour, rich texture, and symbolism. They have been compared to stained-glass windows because of their glowing colours and bold black lines. Rattner often used words and inscriptions in his works. He painted many familiar Biblical themes, including the Crucifixion and the Last Judgment. He also painted less familiar Biblical subjects, such as the Valley of Dry Bones. He developed personal symbolic themes. For example, he painted a window cleaner removing dirt from a window. This is a symbol of the way God clears human vision to enable people to see the brilliance and beauty of the divine. Rattner was born in Poughkeepsie, New York.

Rauschenberg, Robert (1925-), is an American artist famous for experimenting with a variety of materials, techniques, media, and styles. His search for new forms of expression inspired many artists.

Rauschenberg was born in Port Arthur, Texas. He first attracted attention in the early 1950's with all-white and all-black paintings. He then turned to *combines,* or *assemblages,* which combined painting with everyday objects. One combine called *Bed* (1955) consisted of a real quilt, sheet, and pillow, all splattered with paint.


A rattlesnake has a forked tongue, *left,* that helps it detect odours. Its backbone, *centre,* has about 200 flexible joints. The rattle on its tail, *right,* is a set of loosely interlocking segments.

Nelson Atkins Museum, Kansas City, Missouri, U.S.A.

Rauschenberg's *Tracer* reproduces unrelated realistic images with oil paint and the silk-screen printing process to achieve an unusual effect. The artist completed the picture in 1963.

Starting in the early 1960's, Rauschenberg combined printmaking techniques, such as lithography, with drawing and painting. He used silk-screen printing to reproduce newspaper and magazine illustrations of objects and people. He then arranged and repeated the images in his works. His use of images taken from everyday life formed part of the pop art movement during the 1960's (see **Pop art**). During the 1960's, he incorporated electronic systems with painting and other media to present images and invite audience participation. For example, in the *Revolver* series (1967), viewers pressed buttons that rotated discs bearing silk-screen images.

In the 1970's, Rauschenberg again added such materials as cardboard, wood, and fabric to large paintings, notably *Rodeo Palace* (1976). In addition, he created his *Jammer* series (1975-1976). The silk and wood works resemble delicately coloured sails.

Rauwolfia serpentina. See **Reserpine.**

Ravel, Maurice (1875-1937), was a French composer. Ravel's music is finely crafted, and his piano music is especially brilliant. Some critics classify him as an impressionist along with Claude Debussy. Ravel's piano works *Mirrors* (1906) and *Gaspard de la nuit* (1909) fall into the impressionist category. However, Ravel's music is generally less experimental than Debussy's and relies more on the forms and mannerisms of earlier periods.

Ravel used classical forms in his early String Quartet (1904) and *Sonatine* for piano (1906) and in his late Piano Concerto in G (1932). *The Tomb of Couperin* (1919) takes the form of a baroque keyboard suite. His orchestral suite *La Valse* (1920) paints an exaggerated portrait of the Viennese waltz of the 1800's. A more modern influence, jazz, can be found in portions of the *Concerto for Left Hand* (1932) for piano. Ravel was especially known for his skill as an orchestrator. His orchestration of Modest Mussorgsky's *Pictures at an Exhibition* (1922) is a standard symphonic work.

Joseph Maurice Ravel was born in Ciboure, near the Spanish border. A Spanish influence is evident in some of his works, notably in the comic opera *The Spanish Hour* (1911) and in his most popular composition, the ballet music *Boléro* (1928).

Raven is a large all-black bird of the crow family. There are several species of raven. The *common raven* of the Northern Hemisphere has the widest distribution. Other species include the *Australian raven*, the *brown-necked raven* of Africa and the Middle East, and the *white-necked raven* of east and south Africa.

The common raven is 55 to 70 centimetres long and has a wingspread of 90 centimetres. Its black feathers have a bluish-green lustre on the head, wings, and underparts. Feathers elsewhere on the bird have a purplish-blue lustre. The raven's voice is a deep, rumbling croak. Ravens feed on insects, worms, young birds, frogs, and other small animals. They also eat fruit, grain, and *carrion* (the flesh of dead animals).

Ravens build their nests in late winter on cliffs or in trees. The outer part of the nest is made of sticks reinforced with lumps of earth and grass. The deep inner cup of the nest is lined with fine strands of wool, hair, and plant fibres.

The female raven lays 3 to 6 spotted eggs that may vary widely in colour. The female *incubates* (sits on and warms) the eggs. The eggs hatch after about 18 days. Both parents feed the young. They prepare the food by thoroughly crushing insects and by removing the hair, feathers, and bones from birds and other small animals. Young ravens can fly at about 6 weeks of age, but the

The raven has black feathers with a purple lustre. Ravens are often mentioned in myths and legends as magical birds.

parents continue to care for them for another five months.

The raven is one of the first birds mentioned in mythology. In Norse mythology, the god Odin had two sacred ravens that flew about the world each day and returned at evening to tell Odin all they had seen. In American literature, the bird was immortalized by Edgar Allan Poe in his famous poem "The Raven."

Scientific classification. Ravens belong to the crow family, Corvidae. The common raven is *Corvus corax,* the Australian raven is *C. coronoides,* the the brown-necked raven is *C. ruficollis,* and the African white-necked raven is *C. albicollis.*

Ravenna (pop. 135,844) is a city in northern Italy, famous for its art treasures and architecture. It is also an agricultural and manufacturing centre. A 10-kilometre canal connects Ravenna with the Adriatic Sea. For the location of Ravenna, see **Italy** (political map).

Ravenna's Mausoleum of Galla Placidia, built about A.D. 440, is one of the oldest examples of early Christian architecture. It has some of the most beautiful mosaics in Ravenna. The famous churches of San Vitale, Sant' Apollinare Nuovo, and Sant' Apollinare in Classe, built in the 500's, also contain beautiful mosaics.

Ravenna served as the capital of the West Roman Empire from about 402 until the barbarian leader Odoacer seized the empire in 476. Then Theodoric, king of the Ostrogoths, murdered Odoacer and took over the city. Ravenna was part of the Byzantine Empire from about 540 until the 700's. It was one of the Papal States for many years, and it became part of the Kingdom of Sardinia in 1860. Ravenna became part of the Kingdom of Italy in 1861.

See also **Clothing** (picture: Clothing of early Byzantine times).

Rawlings, Marjorie Kinnan (1896-1953), was an American novelist who wrote about the conflict between people and nature in the Florida backwoods. In 1928, Rawlings gave up a journalism career to settle on a farm in Cross Creek, Florida. Her difficult life there gave her the setting and theme for her novels. Her best-known work, *The Yearling,* won the 1939 Pulitzer Prize for fiction. The novel is set in the 1870's. It tells the story of a 12-year-old boy whose father must kill the boy's pet fawn because it was eating the family's scanty crops.

Marjorie Kinnan was born in Washington, D.C., and married Charles Rawlings in 1919. Her other novels include *South Moon Under* (1933) and *Golden Apples* (1935). Her stories were collected in *When the Whippoorwill* (1940). Rawlings humorously described her life in Florida in *Cross Creek* (1942).

Rawlinson, Sir Henry (1810-1895), an expert on ancient Assyria, deciphered the cuneiform inscription of Darius Hystaspes, king of Persia, written in the 500's B.C. (see **Cuneiform**). This enabled students of language to understand many languages used along the eastern coast of the Mediterranean in ancient times. Rawlinson's excavations in Babylonia for the British Museum yielded many valuable sculptures. Henry Greswicke Rawlinson was born at Chadlington, in Oxfordshire, England.

Rawsthorne, Alan (1905-1971), a leading British composer, became known for the *atonal* (keyless) quality of his music. He composed in many forms, writing for chamber groups, for string orchestra, for solo instruments with orchestra, and for voices, both solo and choral. He also wrote incidental music for films and radio. Rawsthorne was born at Haslingden, in Lancashire.

Ray is any member of a group of about 350 species of fishes. These fishes include eagle rays, guitarfish, manta rays, sawfish, skates, sting rays, and torpedoes.

Most rays live on the sea floor. They feed on such bottom-dwelling creatures as clams, oysters, shellfish, and certain fishes. Many species dwell in coastal waters, but a few live at great depths. Manta rays live in the upper waters of the open sea and feed on small sea animals and tiny organisms called *plankton.*

Rays, like sharks, have a boneless skeleton made of a tough, elastic substance called *cartilage.* Rays also resemble sharks in having slotlike body openings called *gill slits* that lead from the gills. But a ray's gill slits lie under the *pectoral* (side) fins, and a shark's are on the sides of the head. Most rays have a flat, disclike body. Among many species, the pectoral fins form large "wings." Guitarfish and sawfish have a more sharklike, torpedo-shaped body.

Ray eggs, unlike those of most other fishes, are fertilized inside the female's body. Female skates lay the fertilized eggs protected in horny capsules. The empty egg cases of the European thornback ray are washed up on beaches and are known as *mermaid's purses.*

Scientific classification. Rays belong to the family Rajidae. The thornback ray is Raja clavata.

See also **Sawfish; Skate; Stingray; Torpedo ray; Fish** (pictures: Fish of coastal waters).

Ray, James Earl. See **King, Martin Luther, Jr.**

Ray, John (1627-1705), a British naturalist, is regarded as the founder of systematic zoology. From 1662 to 1666, he travelled throughout western Europe with a pupil named Francis Willughby. They collected specimens and attempted to classify them. At first, Ray classified plant life and Willughby classified animal life. But, after Willughby died, Ray continued Willughby's work on animal life. Ray was born at Black Notley, in Essex.

Ray, Satyajit (1921-1992), was one of India's leading film directors. Most of his films are in the Bengali language. Ray's first production, *Pather Panchali (Songs of the Road),* won him an award for "best human documentary" at the 1956 Cannes Film Festival. The films he has made since that early success have furthered his international reputation. He received an honorary Oscar shortly before his death in 1992.

Satyajit Ray was born in Calcutta and educated at the Presidency College there. From 1943 to 1956, he worked as a commercial artist for an advertising firm. He then left advertising to devote himself to making films. Most of his actors in *Pather Panchali* were untrained and his film crew lacked experience. *Pather Panchali* was the first of three films telling the story of Apu, son of a poor Brahmin family in a Bengal village. Ray was involved in every aspect of direction and production, including camera work, music, costume, and set design. Many of his later successful films, such as *Ghare Baire (The Home and the World)* (1984) are adaptations of stories by the Bengali author Rabindranath Tagore.

Rayon is a manufactured fibre produced from wood or cotton. It is widely used to make industrial materials and knit and woven textiles for clothing and decorating fabrics. Some rayon fabrics are made heat resistant and used in certain spacecraft parts.

How rayon is made. Rayon is manufactured from the cellulose fibre of wood pulp or cotton (see **Cellulose**). Various chemical processes reduce the cellulose to a thick liquid from which the rayon threads are made. The liquid cellulose is then forced through extremely small openings in devices called *spinnerets* to form *filaments*, or tiny threads. The three chief methods for making rayon are (1) the viscose process, (2) the cuprammonium process, and (3) the acetate process.

The viscose process is the usual method of changing wood or cotton cellulose into rayon. This process begins by soaking sheets of white pulp in a solution of sodium hydroxide. After the soaked sheets are removed, they are put through presses that squeeze out the excess solution. The sheets of cellulose then pass through shredding machines where they are made into fine pieces called *crumbs*. The crumbs of cellulose are aged at high temperatures for about a day. Aging helps determine what type of viscose yarn will be produced.

After aging, the crumbs are treated with carbon disulphide, which turns them to *cellulose xanthate*, a deep orange substance. Then the crumbs are dissolved in a weak solution of sodium hydroxide. This turns the mixture to a thick, syrupy solution, which "ripens" for up to four or five days at a low temperature. When the solution has ripened, it is pumped to spinning machines and forced through spinnerets to form filaments.

The cuprammonium process is a method of dissolving cotton cellulose in a copper-ammonia solution. A special spinning process produces yarns of ultrafine *denier*, or weight.

The acetate process changes the properties of cellulose by treating it in acetic anhydride and acetic acid, with sulphuric acid. The result is *cellulose acetate*, which is then dissolved in acetone to form a syruplike solution.

Spinning. All rayon-making centres about the spinneret, which contains a plate with tiny holes. Pumps force the cellulose through these holes. The threadlike cellulose then flows into a chemical bath that hardens the liquid into threads. The threads are twisted together to form rayon yarn. The yarns are woven into fabrics that look like cotton, wool, or spun silk.

Properties of rayon. Viscose and cuprammonium rayons have much the same chemical properties. Both dye easily, and both lose their strength when wet. They regain their original strength when dry. The wet strength of rayon can be considerably improved by varying the chemical bath composition.

Acetate reacts to heat, and may be burned when ironing. Boiling water takes out its lustre. But acetate has special qualities, such as fineness, texture, and ability to take dye. It can also be permanently pleated.

History. In 1884, the French inventor and industrialist Hilaire Chardonnet patented the first practical synthetic fibre (see **Chardonnet, Hilaire**). He called it *artificial silk*. In 1924, it was named *rayon*, the *ray* indicating the sheen, and the *on* showing that it was a cottonlike fibre.

See also **Fibre** (Manufactured fibres); **Flannel**.

Raziyah, Sultana (? -1240), an Indian ruler, reigned from 1236 to 1240. She was the first woman in the history of Islam to govern a country. Her name is also spelled *Raziya*.

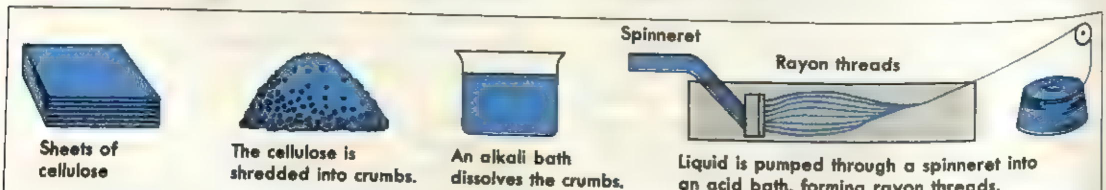
Raziyah's father was Iltutmish, who founded the so-called *Slave Dynasty*. He made Delhi his capital, and from it governed northern India. Iltutmish was impressed with his daughter's ability. As a result, he twice left her in charge of the government, in preference to his sons, while he went off on military campaigns.

Raziyah eventually succeeded her father as ruler. Iltutmish's former advisers were unhappy about this, but they accepted the situation. She dressed as a man. She proved to be a capable and vigorous ruler, giving out justice in person and leading her armies into battle against rebel forces. Raziyah was later overthrown by an army coup and sent to prison. She married her gaoler and attempted to regain her throne with his help, but was finally captured and executed.

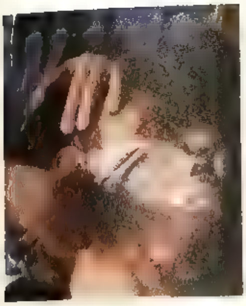
Razor is a cutting instrument used to remove hair from the skin. There are three chief kinds of razors: (1) safety razors, (2) straight-edged razors, and (3) electric razors.

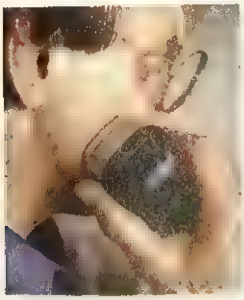
Safety razors have blades that are shielded by metal or plastic holders. The holders make it difficult for a person to be cut deeply while shaving. The blade may have a cutting edge on one side or on both. It may be made of stainless steel and have chromium or platinum edges to prolong sharpness. After the blade becomes dull, it is replaced by a new one. Some razors use two replaceable blades, positioned one on top of the other. Others have a replaceable metal band that can be unwound to expose a fresh cutting edge. Disposable safety razors do not have replaceable blades. These inexpensive razors are thrown away after the blade becomes blunt.

Straight-edged razors have specially tempered steel blades about 8 to 10 centimetres long. The blade has a rounded back and slopes to a fine edge. It is usually fastened by a rivet to a handle of two pieces of metal, ivory, or bone. The blade rests in the handle when not in use. It closes like a springless knife. The best blades were formerly made in Sheffield, England, but a number of factories in other parts of the world now make blades as fine as the best Sheffield razors.



In the viscose process of making rayon, cellulose fibres from wood pulp or cotton are formed into sheets and treated with sodium hydroxide. The cellulose is then shredded into crumbs, treated with carbon disulphide, and dissolved in an alkali bath. Next, pumps force the liquid through the tiny holes of a device called a *spinneret* and into an acid bath to form rayon threads.





People use three main kinds of razors. A straight-edged razor, *above left*, is used by most barbers. It must be handled skilfully to avoid cuts. A safety razor, *above*, has a shielded blade to prevent deep cuts. Many men and women think an electric razor, *left*, is the easiest kind to use.

A good straight razor will last a long time if given good care. The razor wears well if the shaver soaks his face with lather before shaving. When a person shaves, the edge of the blade actually bends, causing it to become blunt. The cutting edge should be smoothed with a leather strop before it is used. The blade must be *honed* (sharpened) regularly.

Electric razors are widely used. These little machines are powered by small electric motors. The cutting head passes over the skin and clips the hair. The head may become blunt after continued use, and may need either sharpening or replacing. The heads of many electric shavers can be adjusted for different beards. Some shavers have built-in auxiliary clippers that can trim long hairs and sideburns. Most cutting heads must be cleaned from time to time.

RDX is a powerful explosive also known as *cyclonite* and *hexogen*. During World War II, RDX was widely used as the chief explosive charge in bombs. It is still an important military explosive, and also has wide use in detonators and fuses. RDX is made by the action of nitric acid on hexamethylene-tetramine, a product of formaldehyde and ammonia. When RDX is mixed with liquid TNT, an explosive called *Composition B* is formed. This explosive is more powerful than TNT, and has replaced it in most artillery shells.

Re, also spelled *Ra,* was the sun god in Egyptian mythology. He was a popular god often merged with other Egyptian deities, so he is often portrayed in various forms. The sun god was often shown as a simple sun disc. He also appeared as a child rising from a lotus, and as a bird, a lion, and a cat.

There are more myths and legends about Re than about any other Egyptian god. Some myths tell about the creation of the world and descriptions of his daily rebirth and perilous journey in his boats through the sky and the underworld. Others tell about Re's ruling on earth as king, and about his becoming the father of three pharaohs.

Heliopolis was an early centre for the worship of the sun god. There Re assumed many of the characteristics of Atum, an early sun god who created the world. By Dynasty V (2494-2345 B.C.), Egyptians regarded the sun as their chief deity. From that time, every Egyptian king was given the title "son of Re." When other gods were later considered universal rulers, they absorbed Re's solar nature and had his name joined to theirs, as in Amon-Re and Sobek-Re.

See also **Mythology** (Egyptian mythology); **Egypt, Ancient** (Gods and goddesses; History: The New Kingdom); **Amon.**

Reaction, in physics. See **Rocket** (How rockets work).

Reaction, Chemical. See **Chemical reaction.**

Reactionary. See **Conservatism.**

Reactor, Nuclear. See **Nuclear reactor.**

Read, Sir Herbert (1893-1968), was a British scholar, poet, and critic. His published poetry includes *Naked Warriors* (1919), *Thirty-Five Poems* (1940), and *World Within a War* (1944). He was the author of books of essays, and critical works on literature and art, among them *Reason and Romanticism* (1926), *English Prose Style* (1928), *The Meaning of Art* (1931), *Form in Modern Poetry* (1932), *A Letter to a Young Painter* (1962), and *To Hell with Culture* (1963).

Read was born at Kirkbymoorside, in North Yorkshire, and was educated at Halifax and at Leeds University. He served in the British Army during World War I.

Reade, Charles (1814-1884), was an English novelist and playwright. His *The Cloister and the Hearth* (1861) has been called the greatest historical novel in the English language. It is an exciting love story that also provides a good picture of life in the 1400's.

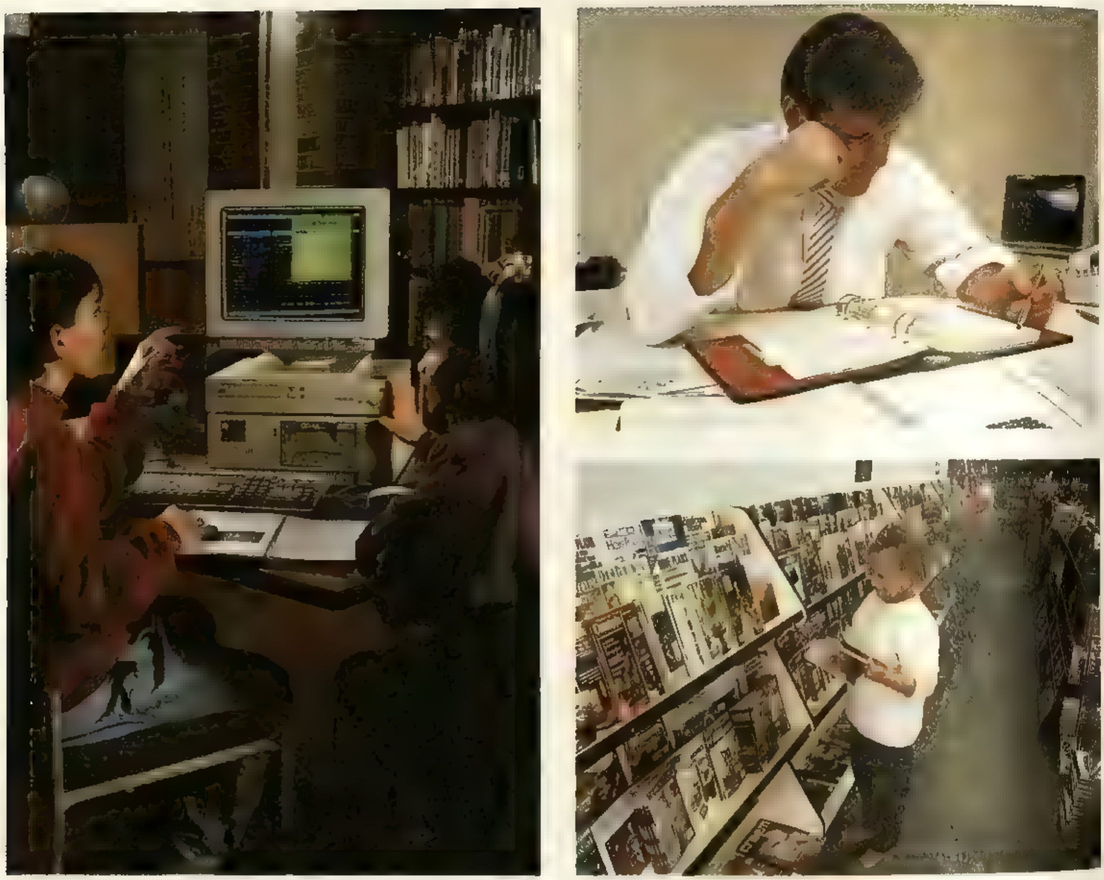
Many of Reade's 23 other novels attack social abuses of his day. For example, he criticized harsh treatment of the insane in *Hard Cash* (1863) and British trade unions in *Put Yourself in His Place* (1870). *It's Never Too Late to Mend* (1856) exposed terrible prison conditions. Reade wrote 20 plays. Several of the plays are adaptations of his novels. Reade kept large files of clippings, and of his own notes about what he saw. He referred to these when writing and thus was able to produce highly realistic accounts of life in the 1800's.

Reade was born at Ipsden, Oxfordshire. He attended Oxford University and became a lawyer. He never practised law, however.

Reading (pop. 122,600) is the administrative centre of the English county of Berkshire. It is a local government district centred on the town of Reading, which is situated on the River Kennet near its junction with the River Thames. The district also takes in several surrounding villages, including Mapledurham, site of a Tudor manor house.

The town of Reading has some light-engineering industries and a large brewery. There are also several headquarters offices of large companies, representing such fields as computers. Reading has the remains of a Norman abbey, where Henry I was buried. The abbey gateway is now a museum. The town is also the home of Reading University, which is well known for its agricultural school. Reading School was founded in 1486. Oscar Wilde wrote *The Ballad of Reading Gaol* (1898) while he was imprisoned at Reading.

See also **Berkshire.**



Reading is important at school, at work, and during leisure time. Students may read information from a computer disk for a class project. An executive may read a financial report or business plan. People may read magazines on home decorating or many other topics that interest them.

Reading

Reading is the act of getting meaning from printed or written words. It is basic to learning and one of the most important skills in everyday life. Reading provides the key to all kinds of information. It enables us to learn how to build or fix things, to enjoy stories, to discover what other people believe, to exercise our imaginations, to broaden our interests, and to develop ideas and beliefs of our own.

People may read hundreds or thousands of words a day without even looking at a book, newspaper, or magazine. For example, they read their mail, street signs, traffic directions, billboards, the printing on television commercials, package labels, and many other things that contain words.

In the simplest sense, reading means recognizing letters and groups of letters as symbols that stand for particular sounds. The sounds, in turn, form words that express ideas in written or printed form. A broader definition of reading links it more closely with other uses of language and with thinking. According to that definition, reading first depends on a reader's memory and experience to understand what is read. It then involves how well the reader remembers, uses, and reacts to the material.

In most cases, the teaching of reading stresses certain skills, such as word recognition, vocabulary development, and *comprehension* (understanding of reading matter). However, the best way to learn to read may simply be just to read. Adults, especially parents, teachers, and librarians, can help children become good readers by reading to them and by encouraging them to read many kinds of materials—and to read often.

The ability to read and write is called *literacy,* and a person who can read is said to be *literate.* A person who cannot read is *illiterate.*

The importance of reading

Reading plays an essential role in the daily lives of most people. People read road signs, maps, recipes, labels on medicine bottles, and directions for operating new appliances. They read and fill out forms for their income tax, to apply for jobs, and to request credit. The ability to perform such useful activities is sometimes called *functional reading* or *functional literacy.*

A special kind of functional reading, *learner literacy,* has always been important to students. All primary school subjects, such as mathematics, science, social studies, and spelling, require students to read. In secondary school and college, learner literacy becomes even more vital. Older students must read to gain an understanding of a wide variety of topics. Learner literacy also requires the ability to read special kinds of materials, including charts, graphs, maps, and tables. People learn throughout their lives, and so such reading skills remain useful after a person has completed school.

Another kind of functional literacy, *workplace literacy,* concerns the ability to read written materials necessary for doing a job. Such materials include manuals on how to operate computers, robots, and other technical devices. In addition, being promoted often involves special training classes and workshops that call for particular reading skills. This is one way that a person's ability to read directly influences job success.

Besides reading in the classroom and on the job, people read books, magazines, and other printed materials for personal information and recreation. Many people read to learn more about their special interests, such as sports, science, current events, history, health, flowers, or painting. Millions of people read novels, adventure stories, biographies, and other books for fun. Recreational reading helps people understand others, takes readers on journeys to unknown parts of the world, and enables them to share the experiences of people throughout history.

As television became a major part of modern life, some experts predicted that people would not need or want to read as much as before. However, books, magazines, and newspapers still fill shelves in bookshops, newsagents, and supermarkets, as well as in libraries. Some experts believe that the information and entertainment provided by TV and related technologies have exposed people to new ideas and interests and so have created additional reasons to read.

Kinds of reading

People differ in reading ability. For example, those who have been reading a long time tend to understand what they read more quickly and more automatically than do new readers. In addition, older readers bring more background experiences to their reading. They can use their experiences to fill in important information that is not clearly stated in the text.

Regardless of age, training, and other experiences, reading abilities and habits vary from person to person. Some people read remarkably fast, while understanding the main points and remembering key examples. Others read at a snail's pace as they try to absorb every word—sometimes without evaluating the worth of the information.

A good reader uses various reading techniques. The technique depends on the type and difficulty of the material, the purpose for reading it, and the reader's own language development and familiarity with the subject.

Reading can be classified into three main kinds: (1) recreational reading, (2) study-type reading, and (3) survey reading. Good readers can easily shift from one kind to another, depending on their purpose for reading and on the material itself.

Recreational reading can provide hour after hour of enjoyment. When reading a story purely for pleasure, most people read at a relaxed, uneven speed. They may skim through a tale until they come to a scene, a description, or even a phrase that is especially pleasing or satisfying. That portion may be read slowly and then reread to be enjoyed, appreciated, or considered.

Study-type reading usually requires the reader to pay close attention to the text. A good reader looks for significant ideas and details. The reader then tries to understand how those ideas and details relate to one another and how they fit into the general topic. Reading speed tends to be slower the first time study-type material is read, and the reader may need to reread portions of the text to understand it fully. Reading speed may be much faster when the material is reviewed.

Survey reading involves covering a large amount of text to get a general idea of its content. In such cases, the person may first skim the material to understand the main point. The reader may then look for details that reinforce or illustrate that point. If the purpose is to find a particular fact or example, the reader may begin by skimming the text. The person may then read some sections carefully to make sure that the desired information has been found.

Shifting among kinds of reading. Most people use different reading techniques for different reading situations. For example, a mystery enjoyed simply for entertainment may be read rapidly. But a classic Russian novel may call for slow, careful reading. Technical texts that could lead to job advancement or that tell how to fix something usually require thoughtful reading.

Good readers can easily shift from one kind of reading to another. For instance, a student collecting information to write a paper might begin surveying articles to see if they fit the topic. One article may lead the student to consider changing the topic, and so the article is studied thoroughly and another topic chosen. While surveying for the new topic, the student looks for information to create an outline. During the survey reading, the student may see an entertaining article and read it for pleasure.

Reading flexibility improves with experience. Beginners may tend to read everything somewhat awkwardly, advancing slowly word by word because they doubt their ability to recognize words. By reading materials that follow their own *language patterns*—that is, familiar words and sentences they use—even beginning readers can read with both speed and understanding. In time, they learn that different reading materials make different demands on their abilities.

How we read

Reading depends first on our *perceiving* (seeing and recognizing) written or printed letters and words. We must then be able to comprehend what we perceive.

Perceiving reading matter. The process of reading begins as our eyes see *visual stimuli*—that is, the printed or written symbols that make up what is to be read. Eye movements across the symbols capture the stimuli. Eye movements called *saccadic movements* take place as our eyes move across a page, pausing briefly to take in groups of words. As our eyes move across a line, they alternately pause and move on. The pauses are called

fixations. Another type of eye movement, *regression,* occurs when our eyes shift back to reread a word or group of words. To move from one line of type to the next, our eyes use a movement called a *return sweep.* However, good readers are unaware of their eye movements as they read.

Nerve cells in our eyes change the visual stimuli into electrical impulses that travel to the vision centre of the brain. The vision centre then sends the impulses to the specific areas of the brain responsible for thought organization, memory storage, and reasoning. Those areas identify the printed and written symbols and translate them into meaning. The physical process of reading also includes the storage of the sounds, meanings, and pictorial representations of what we read.

Comprehending what is perceived. Reading involves far more than simply seeing visual stimuli. You must first choose a particular text to satisfy some purpose. That purpose not only determines the selection of the text but also helps you decide which experiences and reading skills to use to comprehend the material. Your purpose may also suggest how you might use any new knowledge or understanding that you gain from the material.

While reading, you draw on numerous ideas and feelings stored in your memory. Those ideas and feelings make up your *background.* You also rely on *verbal memory*—that is, an understanding of how words come together and form more complex ideas.

Your background and verbal memory change and grow with each reading experience. Information in new material blends with your past experiences and may correct misunderstandings, provide fresh knowledge, broaden interests, or help solve problems.

In many cases, readers lack the background and verbal memory needed to comprehend a text quickly and easily. Such readers may use techniques called *word-recognition strategies.* The more experienced a reader becomes, the more automatically the reader applies these strategies to comprehend unfamiliar words.

Readers can use several general types of word-recognition strategies. For example, a reader who does not know the meaning of a particular word may look for *context clues* in the surrounding text. These clues may be either *semantic* or *syntactic.* When using semantic clues, the reader tries to relate the word to other information or illustrations in the material. Semantic clues include comparisons and contrasts, definitions, descriptions, and the placement of new words near familiar words that help explain their meaning. A reader may also rely on syntactic clues—that is, the word's position and grammatical use in the text. For example, deciding whether a word is functioning as a noun, verb, adjective, or adverb can help a reader figure out its meaning.

In a word-recognition strategy called *structural analysis,* a reader uses clues within the word itself to guess what the word means. The reader relies on knowledge of the meanings of prefixes, suffixes, *roots* (word bases), compound words, and inflectional endings such as *ed* and *ing,* and of how they are combined. For example, the adverb *undoubtedly* has the prefix *un,* the root *doubt,* the inflectional ending *ed,* and the suffix *ly.* Knowing the meanings of the parts of the word leads the reader to decide that the word means *without doubt.* Some methods of teaching reading drill students on prefixes, suffixes, and the meaning of Latin and Greek roots. But the best way for readers to add such knowledge to verbal memory is to encounter words made of those parts in text they find meaningful, and to use the words in conversation and writing.

A word-recognition strategy called *phonics* uses the relationships between spoken sounds and letters. The word *phonics* comes from a Greek word meaning *sound.* Many beginning readers are taught to "sound out" a word, which they may then recognize if they have heard it before. In that way, a reader learns to associate printed symbols with spoken sounds. For more information on phonics, see the section *The teaching of reading* in this article. See also **Phonics.**

Readability. Reading success is determined not only by how well a person reads, but also by how readable the material is. Important factors that influence the readability of any printed material include (1) the average number of words in sentences, (2) the number of commonly understood words, (3) the average number of syllables in the words, (4) the number of long complex sentences, (5) the number of abstract ideas, and (6) the use of prepositional phrases.

Textbooks, reference books, newspapers, government publications, and informational brochures for consumers can be written at predetermined levels by controlling these factors. A number of formulas have been developed for estimating readability. The approximate reading level of the people who will read the material must be known. However, there is no formula or procedure to predict the attitudes and interests of readers, or to predict their previous knowledge about the subject. These three factors may lead people to read at lower or higher levels than might be predicted by a formula. Today many publishers reject rigid readability formulas, but they continue to design materials to the reading levels of the intended audience.

The teaching of reading

The complexity of the reading process makes it difficult to teach reading by only one method. Instead, most reading teachers use a combination of techniques determined by their own preferences, students' needs, and the instructional materials available. Commonly used teaching programmes include (1) the developmental method, (2) the whole-language philosophy, (3) the language-experience method, (4) phonics instruction, (5) sight words and look-and-say instruction, and (6) individualized reading programmes.

The developmental method uses a series of textbooks called *basal readers.* They serve as the basic reading materials in many schools. Basal readers gradually introduce the skills considered important for new readers, especially word-recognition strategies. The textbooks also give students opportunities to apply and practise the various skills.

The typical basal reader series consists of textbooks for each level of reading instruction. Publishers of these textbooks try to present stories, essays, and other writings to which children can relate. A book may include selections from award-winning literature and classics. In addition to student textbooks, basal programmes provide teacher manuals, student workbooks, tests, and

supplementary materials for each ability level. Teachers who use basal readers generally separate the children into groups according to reading abilities and instructional needs. They can then select the teaching materials that most closely match their teaching goals and the students' needs.

In developmental programmes, most reading lessons involve answering in writing questions about the assignment and completing workbook pages that enable students to practise concepts presented in the reading lesson. A large number of lessons and activities also focus on the development of comprehension and analytical thinking. In addition, many programmes help students determine their purpose for reading and encourage them to select additional reading materials.

Developmental programmes are planned in great detail and enable schools to adjust their reading courses for all levels. However, some experts believe that the programmes emphasize word-recognition strategies over comprehension, especially for beginning readers.

The whole-language philosophy tries to teach children that language is an effective and enjoyable way to communicate. Children learn new words in the reading material itself, where the meanings and uses of the words can be best understood.

The relationships between reading, writing, listening, and speaking are essential to the whole-language philosophy. The method defines writing as speaking in print, reading and listening as means of learning, and writing and reading as two ways of thinking with language. Whole-language teachers introduce children to both oral language and written language at as young an age as possible, sometimes as early as preschool.

The whole-language method states that the best way to learn to read is to read meaningful materials. Whole-language teachers emphasize the purpose for reading and student selection of reading matter. Instead of reading copies of the same textbook, students read materials that reflect their individual interests. They may often choose their own materials from their classroom, school, library, and home collections.

Reading in a whole-language classroom does not follow lessons that foresee reading strategy needs for a particular text. Nor do teachers drill students after reading a particular text on the reading skills used for that text. Instead, practice comes from simply reading more.

Whole-language theory claims that students cannot interpret a text correctly or incorrectly. Teachers encourage students to bring meaning to a text on the basis of their own backgrounds. The teachers assist students in the process by engaging them in conversation, asking thought-provoking questions, and suggesting examples of how they might interpret or respond to the text. A student learns through experience that inappropriate interpretations may lead to unsuccessful applications of what has been read. At the same time, the student learns that fresh, creative interpretations may be effective. Teachers accept any reasonable ideas that result from trying to construct meaning.

Educators who favour the whole-language method believe that reading cannot be analysed in terms of specific strategies or skills. They argue that such analysis detracts from what reading really and simply is—the attempt of a reader to get meaning from a text. However, other educators believe that children learn reading more effectively through more structured programmes that teach various strategies essential to reading.

The language-experience method seeks to develop reading skills by having learners use their own experiences and language abilities. It is based on the belief that "What I can say, I can write. What I can write, I can read." The method helps students understand that written language is simply oral language in printed form. The teacher uses the children's own language patterns and ideas to help them improve skills in reading, writing, listening, and speaking. The method is commonly used in whole-language classrooms and in some developmental programmes.

In language experience, beginning readers create their own texts by dictating story ideas to the teacher. The students base the ideas on their own experiences at home or school. The teacher writes the story ideas on a blackboard or on large sheets of paper, creating what are sometimes called *experience charts.* The teacher

The language-experience method of reading instruction encourages beginning readers to tell their own stories to a teacher. The teacher writes the stories on large sheets of paper.

then goes over the experience chart with the class, having individual students read various sentences, reviewing material the class has already learned, or teaching any new words the chart contains. More experienced readers may also write and illustrate the stories themselves to create books for others to read.

Some educators believe that the language-experience method might limit students' learning of different ideas and cultures. But in most cases, teachers soon combine language experience with other methods. Experts who favour language experience believe that it is especially effective in giving children a solid grasp of what reading is—the process of getting meaning from written words.

Phonics instruction teaches children to relate letters to sounds. Phonics is actually a word-recognition strategy that becomes a teaching method only through heavy emphasis. Using phonetic principles, youngsters learn to associate the correct sound with each part of a word and to recognize and pronounce words.

Teachers of phonics assume that children know certain words from hearing them. They also assume that children can learn that the various sounds of spoken language, called *phonemes,* are represented by specific letters and letter combinations, called *graphemes.* Phonics instruction generally begins with teaching the sounds of initial consonants in words and of some vowel sounds. It moves on to consonants at the end of words, additional vowel sounds, and consonant combinations, such as *ch* in *chair* and *sh* in *wish.* Students also learn certain rules for sounding out words. For example, they are taught that when a word contains two vowels and one of them is a final *e,* as in *hole,* the final *e* is silent while the sound of the first vowel is long and so sounds like the name of the letter.

Phonics can be taught in two general ways. *Synthetic,* or *deductive, phonics* deals with the relationships between individual letters and sounds. Children then learn to split graphemes and to blend the phonemes they represent into words. They *synthesize* (sound out) the sounds that form unfamiliar words. Synthetic phonics has helped some people with severe reading problems. But it may limit a reader's ability to quickly grasp the ideas represented by groups of words. In *analytic,* or *inductive, phonics,* children analyse words for their sounds. Instruction begins by teaching the relationships between letters and sounds by referring to words the students know by sight. The teacher may then present other words that begin or end with the same letter and sound. Consonant and vowel combinations are also taught that way. Beginning readers eventually learn to recognize the sounds of new words.

Phonics instruction helps students identify words by their sounds. The reader on the right is pronouncing words to his partner, who identifies them in a workbook.

The great irregularity in the relationships between letters and sounds in the English language presents difficulty if reading instruction heavily emphasizes phonics. Many sounds may be spelled in several ways. For example, the words *beat* and *beet, size* and *sighs,* and *eight* and *ate* sound the same but have different spellings and meanings. In addition, the same letters and letter combinations can stand for several sounds. For instance, the word *tear* is pronounced one way if it means to rip and another way if it means a drop of water from the eye. Some phonics instruction tries to deal with such irregularities through numerous complex exceptions to the rules of sounding out words.

A knowledge of phonics enables a person to determine the sounds of many unfamiliar words. Phonics can also help primary-school children to learn to read. But the majority of experts believe that phonics becomes most effective when combined with other methods that stress meaning and comprehension.

Sight words and look-and-say instruction. If a reader recognizes a series of letters as soon as they are seen as a word, it is considered a *sight word.* Such a word communicates its meaning to the reader so fast that the process seems automatic. Sight-word instruction grew out of the assumption that children probably learn to identify words first by either their appearance or the context in which they appear. They learn to recognize the form of many words from simple books, programme titles and commercials on television, and labels on various products. The beginning reader must acquire a basic sight vocabulary that includes the words used most frequently in spoken language. The same words also occur often in written language. Children can be helped to recognize basic sight words by practising them.

Some reading authorities believe that new words can be taught as sight words, without any analysis of the sounds they require. Children learn many common words that way. In the 1930's, an extension of the practice led to a method called *look-and-say instruction* or *whole-word identification.* The technique stresses word recognition. Phonetic principles may unconsciously aid word recognition in the method. Reading teachers no longer emphasize look-and-say learning, but the development of a vocabulary of sight words remains part of the reading instruction in many classrooms.

Individualized reading programmes take into account the wide range of reading abilities and needs. Such programmes adjust instruction and reading materials to the reading achievement, interests, and ability of each student. The classrooms and school libraries have books and other reading matter that cover many ability levels and fields of interest. An individualized reading programme requires careful supervision by the teacher, who must check each child's progress in skills, attitudes, and interests. Individual children progress as rapidly as they can. These programmes may include elements of

A visit to the library enables students to select books on subjects that interest them. Reading about topics they enjoy, or want to know more about, helps children develop their reading abilities.

other teaching methods, such as the whole-language philosophy or the language-experience method.

Computer-assisted instruction may play an important role in individualized reading programmes, though it can also supplement other teaching methods. Computer instruction includes text material followed by questions that test the student's comprehension. In addition, word-processor programmes enable students to create their own stories. Such programmes are also common in language-experience and whole-language classrooms.

Developing good readers

For many years, educators tried to determine *reading readiness*—that is, when children were ready to learn how to read. They believed that visual and listening abilities, personality development, interests and experiences, emotional stability, language achievement, and certain other characteristics indicated reading readiness. The experts generally agreed that by the time boys and girls reached $6\frac{1}{2}$ years of age, the various characteristics had developed enough for children to learn to read. As a result, most schools offered formal reading instruction to youngsters beginning at that age.

Today, most educators question the idea of reading readiness at precisely age $6\frac{1}{2}$. They point out that being $6\frac{1}{2}$ years old does not automatically assure that a child will profit from reading instruction. Some children do not fully develop the skills traditionally associated with reading readiness until age 8. Others have them by age 4. In addition, many experts now believe that learning to read depends mainly on whether a child can focus the mind on letters and words as symbols of meaning. The development of that capacity has come to be called *emergent literacy*—that is, the beginning of the ability to read. The amount of experience a child has had with oral and written language—rather than the child's age—appears to be a key to emergent literacy.

Research shows that children begin to associate sounds with the symbols they stand for at an early age. Very young children with no reading experience may astound their parents with the first words they read, such as a department store sign announcing Big Sale. If children who cannot write are asked to write the story they have been telling orally, they tend to scribble in patterns across a page. Such children show an understanding of what writing is and how it is put on a page.

Research thus demonstrates that children begin to understand language from the time they first listen to adults talk to them. Children try, in turn, to express their needs to adults with a variety of sounds. Emergent literacy suggests that children of all ages can learn from language-related experiences. Children's experiences at home and at school greatly influence how well they learn to read.

Learning in the home. At home, parents and other adults can promote the growth of a child's language-related abilities in many ways. First, they should make sure that the child is physically able to read by watching for vision or hearing problems that could be treated or corrected. Adults should also spend much time talking to the young child in an appealing and clear voice. Such attention will likely arouse the youngster's interest in language and provide opportunities to distinguish various sounds and to build vocabulary. Some adults move attractive objects before a baby's eyes to encourage alertness and to exercise developing *motor skills* (controlled movements) of the eyes and head.

As children begin to use language, parents and other adults should try to converse with them. In so doing, grown-ups should respect a child's interests and ideas and be patient with the youngster's attempts to express them. Adults thereby teach the value of language as a means of communication. They also become a chief source of information for a curious child. Adults can help a child grasp basic ideas and how they relate to one another, such as the difference between *up* and *down* and between *under* and *over*.

Letting a child assist with cooking or building something serves as an excellent way to introduce measurements and an understanding of sizes and proportions. In helping sort the laundry, the youngster can learn to group or classify objects. Such activities aid the devel-

opment of logical-thinking skills and teach the young girl or boy how to follow a sequence of directions.

By reading aloud to a child regularly, an adult can help a child learn to love books and reading. Even a child too young to understand the words will enjoy the closeness of the activity. In selecting reading materials for older children, adults should consider the child's maturity and interests. The youngster can become involved in a story by asking questions or by trying to guess what will happen next. Above all, frequent reading aloud to the child enables the adult to demonstrate the enjoyment that language and reading can provide. Adults can also show how much they like to read by setting aside time to read for their own enjoyment.

Working with the school. Schools build on the language learning begun in the home. Teachers encourage reading development by reading to children, telling them stories, discussing childhood experiences, and providing them with new experiences. Teachers can also give children many opportunities to express themselves orally, and they can write or type simple stories the children dictate. Reading programmes in the early stages stress basic skills essential to gaining independence in recognizing and understanding new words. Such programmes also help children use the words in meaningful sentences and develop interests and attitudes toward reading as a satisfying experience.

A child's progress in becoming an independent reader depends heavily on cooperation between parents and teachers. Parents can reinforce the school's reading instruction by learning about their youngster's school experiences. As the child learns to read, adults should continue to show that they view reading as important, enjoyable, and worthwhile. For example, they can read often and regularly themselves. They can also provide appealing reading matter in the home.

Reading aloud to a child is an enjoyable activity for both the adult and the youngster. In selecting reading materials, adults should consider the child's maturity and interests.

Parents and other adults should find out which topics and school subjects especially interest a child. The information will help them determine how well the school's reading materials serve—or could serve—the youngster's particular interests. Adults themselves may then be led to provide reading matter that the child would gladly turn to. For example, the parent of a teenager might mention what a critic said about a new pop singer in a magazine. A copy of the magazine just happens to be on the coffee table, where the teenager can later discover it and verify or challenge the critic's comments.

Children who care little about school and perform poorly might not have developed the necessary reading abilities to succeed, or they may simply lack interest in the subjects covered. Forcing a youngster to read seldom provides a lasting solution and almost certainly does not contribute to developing a good reader. But appealing to young people's interests and showing how reading can serve them have proved to be successful.

Reading problems

Researchers have long tried to identify the specific reasons why some people do not learn to read as well as others. But the more that researchers have realized how complex the reading process is, the more they have concluded that it is more important to treat the reading problems that arise in an individual child than to find the precise cause of the problems. Some specialists use the term *dyslexia* to cover most reading problems. Narrowly defined, dyslexia refers to a problem in which a reader sees letters or words reversed or upside down. However, such reversals occur fairly often among inexperienced readers. The term has generally lost favour because it came to be used to describe a broad range of reading problems, which led to confusion about its meaning. See **Dyslexia**.

Most specialists prefer the term *reading disability* to describe a lack of the reading development that could be expected in a person with normal vision, normal hearing, and normal or above normal intelligence. Many experts now believe that reading problems have a combination of causes. Many of the causes are so closely interwoven that it is extremely difficult to separate them. In addition, no two readers have exactly the same difficulties. All reading problems should therefore be diagnosed and treated by a specialist. For more information on reading problems, see **Learning disabilities**.

Signs of reading problems. Parents, teachers, and other adults should watch for signs of reading difficulty in children. They should suspect a possible disability if a child dislikes reading, school, and homework. Instead, the child may prefer activities that require little or no use of language. Poor marks at school and teacher concern may result. The child may seek out friends who are not particularly involved or successful at school.

Adults should also consider the possibility of a reading problem if a child has an unusually small vocabulary. A youngster who does not speak well, resists talking with adults, or avoids situations that might involve writing may have trouble understanding both oral language and written language.

Reading disabilities require special teaching methods. This teacher is using individualized reading materials to help a student improve her ability to recognize letters and words.

Causes of reading difficulties. Reading problems can be classified into four general types. They are (1) aliteracy, (2) failure to concentrate, (3) insufficient experience, and (4) physical disabilities.

Aliteracy means the lack of desire to read. Aliterate people can read, but they tend to avoid the activity. Aliteracy reinforces itself—that is, people who do not read much do not develop their reading skills. People usually dislike doing things they do poorly, and so aliterate people tend to read less and less. Such reinforcement becomes especially true in the classroom, where the aliterate student sits among skilled readers.

A solution to aliteracy lies in capturing the student's interest with attractive, meaningful reading materials. The student who learns obviously beneficial things through reading may become a frequent reader.

Failure to concentrate. To get meaning from reading matter, a person must focus the mind on the text. Almost all readers occasionally fail to understand the text their eye movements perceive. Some readers—particularly young ones dealing with assigned material—often try to read that way, as though the process were so automatic as to require no thought. But for comprehension to occur, readers must bring their knowledge and experience to the act of gaining meaning from words. Obviously, comprehension demands paying attention to the topic and what the text appears to say about it.

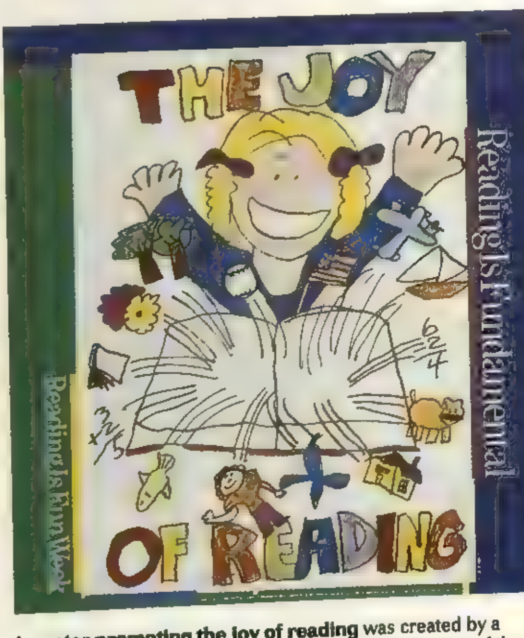
Readers can work to improve comprehension in several ways. First, they should understand the reason for reading a particular text. Readers should then make assumptions and predictions regarding the text to be read based on such things as its title, author, and structure. While reading, they should summarize and evaluate the material. Consulting other resources—such as a dictionary, another text, or a teacher or other adult—can help clarify difficult material.

Insufficient experience. All readers bring their experiences to the comprehension process. Youngsters from homes where conversation, ideas, and printed materials are valued have a broad base of experience and thus an advantage in developing as readers. Children whose experiences have been limited may have more difficulty with reading. In addition, readers may bring considerable background to some topics but little experience to others.

Adults can help children become successful readers by providing them with many varied experiences, especially language-related experiences. The act of reading itself enriches the child's background, and so experience and reading reinforce each other.

Children who speak a language or dialect that is different from the one used in their school may require language-development programmes. Such programmes teach that children can learn more than one language or dialect to take part in mainstream society—and still have pride in their own culture. Many schools in the United Kingdom, Australia, and North America teach English as a second language and provide special instruction for children who speak two languages.

Physical disabilities. Inadequate brain development or vision or hearing defects can cause reading difficulties. However, they account for only a small percentage of all reading problems. Adults will almost certainly notice major brain-development abnormalities in a child long before concerns about the youngster's reading abilities arise. Parents may thus already have been receiving help with the child. However, lesser abnormalities may not appear until the child begins to learn to read. Teachers who notice a large difference between a child's expected reading performance and the youngster's actual achievement may recommend that a paediatrician evaluate the child.



A poster promoting the joy of reading was created by a schoolgirl for a group that works to increase awareness of the importance of reading.

Eliminating illiteracy is an important part of the educational programme of developing nations. The teacher shown above is teaching students in Libya how to read Arabic.

A vision or hearing problem does not by itself cause poor reading. However, correction of such a problem aids reading development. Vision or hearing defects may not become obvious until a child takes screening tests at school, but parents or teachers may notice them earlier. Signs of possible vision problems include frequent rubbing or squinting of the eyes, holding pictures and print close to the face or too far away, and complaining of headaches. Children who do not pay attention, who misunderstand directions or ask to have them repeated, or who have unusual speech habits may experience hearing difficulties. In most cases, vision or hearing problems can be corrected with spectacles or a hearing aid. But for some children, special help with reading is also necessary.

Reading and society

The way of life in any country reflects in large part the percentage of its people who can read and write. The higher the percentage of literate people, the more technologically, scientifically, and economically advanced the way of life.

Most societies therefore value the ability to read and write well. Skilled readers contribute to creating a prosperous, productive society. At the same time, they themselves enjoy fuller, more satisfying lives.

In every society, some people have only basic reading and writing skills. They can read simple signs, package labels, and similar matter. Such functionally literate people can read and write just enough to get by. That limited ability may be adequate in a remote village of a developing country but not in a major city of a modern industrial nation. On the other hand, even highly developed nations have functionally illiterate people. They cannot handle the reading and writing that may be required at work. They may also be unable to use language well enough in other ways to meet the demands of their society.

Figures on literacy around the world are based on estimates made in each country. Not all countries define literacy the same way. But most try to describe some very basic level of reading and writing ability. In 1990, about 73 per cent of the world's population 15 years old or older could read and write. That means about 1 billion people—or 27 per cent of the people that age worldwide—were illiterate. In a number of countries, including Canada, Japan, the United Kingdom, and the United States, about 99 per cent of the people aged 15 or older can read and write. However, functional illiteracy remains a problem in advanced nations.

Africa, Asia, and Latin America have the greatest percentages of illiterate people. The world illiteracy rate, however, has been decreasing. In Latin America, for example, the rate dropped from about 32 per cent in 1960 to about 20 per cent in 1980. See **Illiteracy** (table: Illiteracy rates for selected countries).

Related articles in *World Book* include:

Book
Dictionary
Dyslexia
Encyclopedia
Illiteracy
Initial teaching alphabet
Kindergarten
Language
Learning disabilities
Library
Literature for children
Perception
Phonics
Speed reading
Study
Vocabulary

Outline

I. The importance of reading
II. Kinds of reading
- A. Recreational reading
- B. Study-type reading
- C. Survey reading
- D. Shifting among kinds of reading

III. How we read
- A. Perceiving reading matter
- B. Comprehending what is perceived
- C. Readability

IV. The teaching of reading
- A. The developmental method
- B. The whole-language philosophy
- C. The language-experience method
- D. Phonics instruction
- E. Sight words and look-and-say instruction
- F. Individualized reading programmes

V. Developing good readers
- A. Learning in the home
- B. Working with the school

VI. Reading problems
- A. Signs of reading problems
- B. Causes of reading difficulties

VII. Reading and society

Questions

How can teachers encourage reading development?
Why do most people use different reading techniques for different reading situations?
What is *emergent literacy*?
Why has the ability to read well always been important to students?
How can *context clues* help a reader figure out the meaning of a word?
Why do most societies value reading ability?
What is *aliteracy*? How can it be solved?
In the language-experience method of instruction, how do beginning readers create their own texts?
How can parents and other adults promote language development in children at home?

Reading, Marquess of (1860-1935), Rufus Daniel Isaacs, was British viceroy of India from 1921 until 1926. He was born in London and educated at University College School in London. He had a brilliant career as a barrister before entering politics. In 1904, he was elected Liberal member of Parliament for Reading, Berkshire. In 1910, he was appointed attorney general, and three years later, lord chief justice. In 1917, he was appointed high commissioner and special ambassador to the United States.

Reagan, Ronald Wilson (1911-), was president of the United States from 1981 to 1989. A Republican, he was first elected to the White House in 1980. Reagan was a popular president. He won reelection in 1984 by defeating Walter F. Mondale, the Democratic nominee, by a huge majority.

Ronald Reagan was born on Feb. 6, 1911, in Tampico, Illinois. After graduating from Eureka College, Illinois in 1932, he worked as a sports commentator for a radio station.

In 1937, the American film studio Warner Brothers signed an acting contract with Reagan. Reagan made his film debut in *Love Is On the Air* (1937). During World War II (1939-1945), he spent his time making training films.

Political career. Reagan first won public office in 1966, when he was elected governor of California. He served until 1975, making major political decisions himself but relying on others to handle the details.

In July 1980, Reagan easily won the nomination as Republican candidate for U.S. president. At his request, George Bush, former ambassador to the United Nations, was nominated as vice presidential candidate. As president, Reagan had to deal with many domestic problems. By the end of his first term, rapid inflation had been reduced, unemployment had fallen, and the economy had made a strong recovery.

In foreign affairs, Reagan won a struggle with Congress over his defence programme. The plan called for a large build-up of weapons. The United States and the Soviet Union held talks to reduce nuclear arms, but they failed to reach an agreement. Rebellions in Nicaragua and El Salvador also became a major concern. Cuba and the Soviet Union were giving weapons to the government of Nicaragua and to rebels in El Salvador. The U.S.A. sent advisers and arms to the Nicaraguan rebels, known as the *contras*, and to the Salvadoran government.

During the mid-1980's, Reagan furthered his military defence agenda by expanding the Strategic Defense Initiative, nicknamed "Star Wars," which was designed to develop a space-based missile system. In 1987, Soviet leader Mikhail Gorbachev visited the United States. During the visit, Reagan and Gorbachev signed a treaty that called for the destruction of all ground-launched U.S. and Soviet nuclear missiles with intermediate ranges (500 to 5,500 kilometres).

Reagan and his administration suffered a sharp loss of prestige because of sales of U.S. weapons to Iran and the use of the profits to help the Nicaraguan rebels. Both activities were secret operations, but they became known to the public in November 1986. At the time, the United States had a policy that prohibited the sale of weapons to Iran and other nations considered to be supporters of terrorism. The transfer of funds took place in the mid-1980's. Congress had banned military aid to the contras during that period. Reagan claimed he knew nothing about the fund diversion. In 1987, a report investigating the *Iran-contra affair* strongly criticized Reagan. After leaving office in 1989, Reagan returned to California.

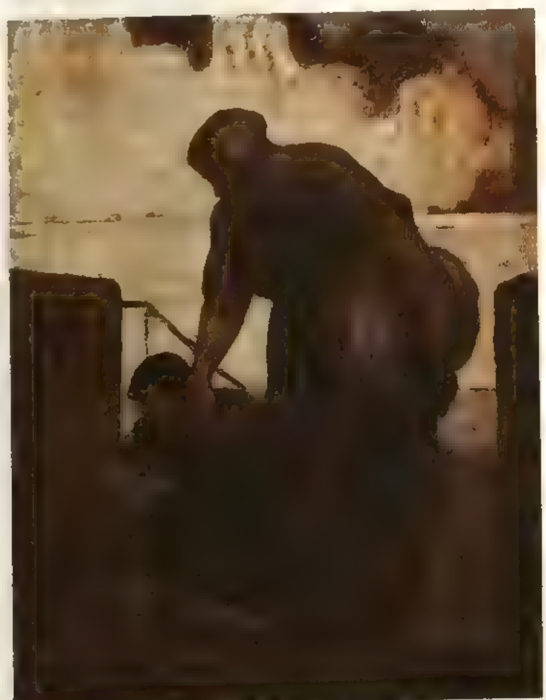
Real tennis. See Royal tennis.

Realism, in the arts, is the attempt to portray life as it is. To the realist, the artist's main function is to describe as accurately and honestly as possible what is observed through the senses.

Realism began as a recognizable movement in the arts in the 1700's. By the mid-1800's, it was a dominant art form. In part, realism has been a revolt against *classicism* and *romanticism*—artistic movements characterized by works that idealize life. The works of classicists show life as being more rational and orderly than it really is. Romanticists' works show life as being more emotionally exciting and satisfying than it normally is.

Realists try to be as objective as possible. They try not to distort life by forcing it to agree with their own desires or with the formulas of art. However, in the process of selecting and presenting their material, they cannot help being influenced by what they feel and think. Even the most thoroughgoing realism, therefore, is the result of observation and personal judgment.

In fiction. Realistic fiction has been primarily a revolt against the sentimentality and melodrama of romantic idealism. Characters in realistic fiction tend to be more complex than those in romantic fiction. Settings are



The Washerwoman (1863), an oil painting on a wood panel; The Louvre, Paris

A realistic painting by the French artist Honoré Daumier shows ordinary people in everyday surroundings.

more ordinary, plots are less important, and themes are less obvious. Most realistic fiction deals with probable, commonplace events and believable people. Much realistic fiction presents unpleasant, and even offensive, subject matter. This sordid quality is especially associated with *naturalism,* an outgrowth from realism.

The growing popularity of realism has been more than simply a reaction against the pretty worlds of romantic fiction. More fundamentally, its popularity has been due to two factors. One is the development of modern science, with its emphasis on detailed reporting. The other is an increasing desire of writers and readers for a realistic understanding of social problems.

In English literature, realism first became important in the 1700's with the work of Daniel Defoe. In the 1800's, realism became much more important in the works of Jane Austen, George Eliot, Thomas Hardy, George Moore, William Makepeace Thackeray, and Anthony Trollope. Honoré de Balzac, Gustave Flaubert, and Stendhal of France; and Leo Tolstoy and Ivan Turgenev of Russia were other outstanding European realists of the 1800's. See **Russian literature** (The age of realism).

Henry James, William Dean Howells, and, to some extent, Mark Twain were the first acknowledged realists in American literature. Stephen Crane, Frank Norris, and Theodore Dreiser were the first American naturalists. In their fiction, and in that of later writers such as Sinclair Lewis, F. Scott Fitzgerald, Ernest Hemingway, and John Steinbeck, realism became so accepted as to make romantic fiction seem outdated.

In drama. As in fiction, realism in drama is an attempt to show life as it is. Realistic drama first developed in Europe as a reaction to the melodramas and sentimental comedies of the early and middle 1800's. It has taken many forms, from the light realism of the comedy of manners to the heavy tragedy of naturalism.

Realistic drama first became important in Europe with the plays of Henrik Ibsen of Norway. Ibsen examined the social issues of his time in such plays as *Pillars of Society* (1877) and *A Doll's House* (1879). Anton Chekhov described Russia's fading aristocracy in *The Cherry Orchard* (1904). The English theatre was slow to accept realism. George Bernard Shaw finally brought the movement to life with his long series of witty plays dealing with social problems, starting with *Widowers' Houses* in 1892. In Ireland, John Millington Synge blended realism and poetry in *Riders to the Sea* (1904). In a similar manner, Sean O'Casey explored the issues of Ireland's struggle for independence from England in *Juno and the Paycock* (1924) and other plays.

Realism made a permanent impact on the theatre with the production of Eugene O'Neill's *Beyond the Horizon* in 1920.

In painting. Realistic painting developed as a reaction to two influential styles of the early 1800's—neoclassicism and romanticism (see **Painting** [The 1800's]). Aspects of realism can be seen in the work of Spanish painter Francisco Goya in the 1700's. Realism gained dominance in European painting in the 1800's with the work of such French artists as Camille Corot, Gustave Courbet, and Honoré Daumier. The French *impressionists* of the late 1800's developed a modified form of realism. In their paintings, realism was narrowed to the brightly lighted but restricted reality that can be seen at a momentary glance (see **Impressionism**).

Realists of the late 1800's included the Americans Thomas Eakins and Winslow Homer. They were followed in the early 1900's by a group called the *Ashcan School* or *The Eight.* This group opposed the sentimentality and academic quality then popular in American art (see **Ashcan School**). They painted realistic street scenes, portraits, and landscapes. Other realists include George Bellows, John Steuart Curry, Edward Hopper, Reginald Marsh, and Grant Wood.

Realism today. In fiction and drama, realism has become so widespread it scarcely has identity as a distinct

Egg tempera painting on canvas (1930); Whitney Museum of American Art, New York City

Realistic art is an attempt to portray life as accurately as possible. The American artist Reginald Marsh painted *Why Not Use the "L"?, left,* and other realistic scenes of everyday life in New York City.

movement. Common realistic themes include the importance of the subconscious, the role of racial minorities in society, and the search for values in a hostile world. During the early 1900's, painters began rejecting realism in favour of nonrepresentational and abstract styles. By the 1980's, realism was often associated with photography rather than with painting.

There is a separate biography in *World Book* for each author and painter discussed in this article.

Reaper is a machine that farmers once used to harvest grain. Horse-drawn reapers took the place of sickles and cradle scythes, which farmers had used for centuries. With a reaper, farmers could harvest larger crops with fewer workers than ever before.

Several reapers were developed during the early 1800's. But none of them became as commercially successful as the reaper developed by the American inventor Cyrus Hall McCormick (see **McCormick, Cyrus Hall**). His reaper had a straight blade linked by gears to a drive wheel. As the wheel turned, the blade moved back and forth and sawed through the stalks of grain. Projecting rods caught and held the stalks while the blade cut through them. The stalks fell onto a platform and a worker raked them onto the ground.

McCormick first offered his reaper for sale in 1840. He continued to improve it, and sales grew. The reaper was well-suited to the American Midwest, where farmers grew wheat and other small grains on fairly level land. However, a crew of eight to ten workers was still needed to bring in the crop. One drove the horse, a second raked the platform, and six to eight workers bound the sheaves. Inventors worked on reducing the number of workers needed.

During the mid-1850's, *self-rake reapers* came into use. On these reapers, a rake swept across the platform. In the early 1870's, the American inventor Sylvanus D. Locke produced a *binder.* This reaper bound the sheaves and dropped them on the ground. By the early 1920's, many farmers used tractors to pull binders. Since the 1920's, reapers have been replaced by combined harvester-threshers called *combine harvesters* (see **Combine Harvester**).

Reason usually has three different meanings. (1) It can signify the mind, or an agency used in thinking. For example, we may ask someone to use reason rather than emotions. (2) Reason also refers to the evidence for a belief, opinion, or judgment. We may demand a reason for a person's belief that someone is a thief. (3) Reason may refer to a process of arriving at a decision or a conclusion. For instance, we may say that a jury was reasoning correctly when it decided a defendant was guilty.

Reasoning can be inductive or deductive. People use *inductive reasoning* when they see a puddle of water and infer that it has rained recently. Inductive reasoning is not conclusive. The evidence only makes the conclusion probable. See **Inductive method**.

People use *deductive reasoning* when they assert that oxygen is present in a place because life is present there and because life requires oxygen. Deductive reasoning shows what else must be true if the initial beliefs are true. See **Deductive method**.

See also **Fallacy; Geometry** (Geometry as a logical system); **Human being; Logic; Philosophy** (Logic).

Reason, Age of. See **Age of Reason**.

Reasoning. See **Logic**.

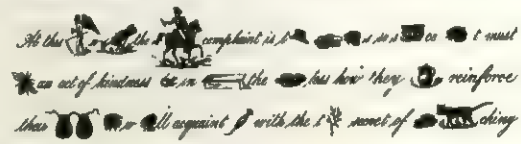
Rebecca. See **Isaac**.

Rebecca riots took place in Wales. They were protests by Welsh farmers against having to pay a *toll* (fee) to use roads. The riots began in 1839 and continued until the Turnpike Act of 1844 abolished many tollgates. Bands of farmers dressed in women's clothes and tore up toll gates. They were called *Rebeccas* from a reference in the Bible, Genesis 24: 60.

The most extreme incident occurred in 1843, when 4,000 Rebeccas on foot and 500 on horseback attacked the Union Workhouse at Carmarthen. Mounted dragoons dispersed them.

Rebozo. See **Mexico** (Clothing).

Rebus is a word game in which the placement or size of letters, numbers, or words indicates names, phrases,



U.S. statesman Benjamin Franklin used rebuses along with script writing in a tract called "The Art of Making Money Plenty."

or other words. A rebus can also have pictures, or words and pictures. For example, a picture of an eye, followed by "CA," followed by a picture of a dog, could stand for "I see a dog." Or, using words and figures:

stand	you	4	my
I	charged		shoes

for "I understand you overcharged for my overshoes."

Recall, in psychology. See **Memory** (Measuring memory).

Receipt is a written statement showing that one person has paid money to another. It may also be a written statement showing that goods, or property, has passed from the ownership or responsibility of one person to another. The receipt is proof that a transaction has taken place. Three kinds of receipts are *receipts in full, receipts on account* (when some of the amount due is paid), and *receipts to apply on special accounts.*

A receipt should always show whether payment is made in full, on account, or on the special account to which payment is made, when there is more than one account between two persons. A receipt should always be given when an account is paid. A bill that has been properly signed and marked *paid* serves as a receipt.

Receiver. See **Radio** (How radio programmes are received); **Telephone** (How a telephone works); **Television** (Receiving television signals).

Recession is a decline in overall business activity. During a nationwide recession, a country suffers a drop in buying, selling, and production, and a rise in unemployment. A recession may also hit an industry or a region. Prices do not always fall during a recession. Because of the lack of demand, production of some goods may become more expensive and prices may rise. A recession hurts countless people, especially the workers who lose their jobs.

Recessions, also known as *contractions,* are part of the *business cycle,* a recurring rise and fall in economic activity. Many economists consider a nation's economy

to be in a recession if the output of goods and services falls for six consecutive months. A recession lasts an average of about a year. A recession that grows worse and lasts longer becomes a *depression.*

Causes of recession. Most recessions occur because the total amount of spending in the economy drops. For example, if sales rise more slowly than usual, businesses may reduce their orders for new goods. The manufacturers that supply the goods cut back on production. They need fewer workers, so redundancies are made and unemployment increases. Workers have less money to spend, which further decreases the demand for goods. As this pattern spreads through the economy, a recession begins.

Government action may trigger the drop in spending. For example, cuts in government spending could reduce the nation's total spending enough to start a recession. Reduced spending also may result if the government conducts a *tight money* policy, which makes bank loans more expensive and harder to obtain.

Other recessions result from shortages of vital products rather than from decreased spending. For example, interruptions in oil shipments have caused recessions in many Western countries.

People's expectations also play an important role in the decline of economic activity. If manufacturers or consumers believe conditions will worsen, they may cut back on their buying. By doing so, they could help bring on the slump they were trying to avoid. This process is called *self-realizing expectation.*

Fighting recession. A government tries to end a recession by means of its *fiscal policy* and *monetary policy.* Fiscal policy deals with a government's spending and taxation. Monetary policy refers to how a government manages the nation's money supply. To halt a recession, a government may boost its own spending, reduce taxes, or increase the money supply. These actions give people more money to spend and thus increase the demand for goods and services.

Many nations also have built-in stabilizers that work to stimulate the economy without any special government action. One such stabilizer is a progressive income tax system, which taxes higher incomes more heavily than lower ones. If a taxpayer's income falls, his or her taxes drop by an even greater percentage. As a result, the person has a larger share of his or her income to spend. Another automatic stabilizer is unemployment benefit, which provides benefit payments from the government for workers who lose their jobs. Such benefit gives these workers less money to spend than they had when they were employed, but more than if they had no income at all.

See also **Business cycle; Depression; Unemployment.**

Recife (pop. 1,184,215; met. area pop. 2,348,362), in northeastern Brazil, is the capital of the state of Pernambuco. Recife lies at the mouths of Capibaribe and Beberibe rivers, partly on the mainland and partly on an island in the Atlantic Ocean (see **Brazil** [political map]).

Factories and mills of Recife produce textiles, ceramics, paper and leather goods, vegetable oils, and alcohol. The city's chief source of wealth comes from the exportation of bananas, coffee, cotton, hides, and sugar. Recife has four universities.

The Portuguese settled the Recife region in 1535. During Dutch invasions of Brazil (1630-1654), Recife was the centre of enemy operations. It became a Brazilian town in 1710, and a city in 1823.

Recombinant DNA. See **Genetic engineering.**

Reconstruction was a period in United States history that followed the American Civil War (1861-1865). During the Reconstruction period, the Union states of the North restored relations with the Confederate states of the South after defeating the South in the Civil War. Reconstruction lasted from 1865 to 1877.

Political leaders of the North and South faced many difficult questions. For example, how should the 11 Southern states that had *seceded* (withdrawn) from the Union be readmitted? How, if at all, should the Confederate leaders be punished? What rights should be granted to slaves freed after the war, and how should these rights be protected?

Lincoln's plan. President Abraham Lincoln proposed that if 10 per cent of a state's voters took an oath to support the Union, the state could form a new government. The state's new constitution had to prohibit slavery.

The Civil War ended on April 9th, 1865. Less than a week later, Lincoln was assassinated. Vice President Andrew Johnson succeeded him as president.

Johnson's plan. Johnson offered pardons to all Southern whites except the main Confederate leaders. The Southern states were to form new governments which had to abolish slavery and vow loyalty to the nation, in order to qualify for readmission to the Union. This plan did not offer blacks a role in the process of Reconstruction.

The black codes. The status of blacks soon became the most crucial issue. The new state governments passed a series of laws called the *black codes,* which enabled the Southerners to retain control over the freed slaves. Whipping of blacks was still permitted, blacks had to sign year-long labour contracts, and unemployed blacks could be sent to jail. They also suffered violent attacks from whites who refused to support the new Reconstruction governments.

Many Southerners considered the governments illegal and could not accept the idea of blacks voting or holding office. In 1865, a secret white organization called the Ku Klux Klan was founded in Tennessee. Klan members beat and even murdered blacks and their white sympathizers. See **Ku Klux Klan.**

New state programmes and policies. The Reconstruction governments established the first free, tax-supported school systems in most states of the South. Blacks flocked to these schools but many whites refused to attend. As a result schools were segregated by race, though this was prohibited by law.

The new governments banned racial discrimination and also guaranteed blacks the right to vote. But, white violence kept blacks from gaining any real rights in spite of the protection of troops from the North.

Major economic problems troubled the Southern governments. Agriculture recovered only slowly after the war and few Southerners had enough money to launch new industries. It was important to attract investment money from the North.

Before the full aims of the Reconstruction governments could be achieved, the 1876 presidential election

brought Rutherford B. Hayes into office. Hayes immediately carried out an agreement to withdraw all federal troops from the South.

Effects of Reconstruction. During Reconstruction, the Union was restored and rebuilding of the South was started. The school systems that were established in the South had lasting importance for the region. However, Reconstruction failed to solve the economic problems of either the blacks or the South as a whole. It also failed to bring racial harmony to the Southern States, and the blacks gradually lost all the rights they had gained. It was not until the mid-1900's that black Americans were able to claim the equality before the law that the Reconstruction governments had promised them.

See also **American Civil War; Black codes; Civil rights.**

Record player is a device that reproduces sounds that have been recorded on audio records. Record players are also called *gramophones* or *phonographs.* They are used widely to play recorded music for listening and dancing. People also listen to gramophone records of dramatic performances, poetry readings, and speeches. Many radio stations use high-quality record players to play records for broadcasting over the airwaves.

There are two main types of record players, each based on a different system of recording and reproducing sound. The older and more common type of record player plays records that have been produced by a process called *analogue recording.* In this process, an *analogue* (likeness) of the original sound waves is stored as jagged waves in a spiral groove on the surface of a plastic disc. As the disc rotates on the record player, a needle, called a *stylus,* rides along the groove. The waves in the groove cause the stylus to vibrate. These vibrations then are transformed into electric signals that may be converted back into sound by speakers.

The other type of record player plays recordings made by a technique called *optical digital recording.* Such recordings are commonly known as compact discs (CD's). The word *disc* is sometimes spelled *disk.* On a CD, sound information is stored in *digital* (numerical) code in the form of tiny pits in the disc. A beam of concentrated light created by a device called a *laser* is reflected from the spinning disc. As the laser beam is reflected, the pits break it up into pulses of light. These pulses of light then are converted into electric signals. The electric signals are decoded and strengthened before they reach the speakers.

Parts of a standard record player

The main parts of a standard record player are (1) the turntable, (2) the drive system, (3) the stylus, (4) the cartridge, (5) the tone arm, and (6) the amplifier. The parts of a compact disc player are somewhat different. For a description of a CD player, see the section *Digital sound recording and reproduction.*

The turntable is a flat metal plate covered with rubber or felt on which the record sits. Most turntables operate at $33\frac{1}{3}$ and 45 revolutions per minute (rpm). Some also operate at 78 rpm.

The drive system spins the turntable. Most record players are equipped with a *belt drive* or a *direct drive.*

A belt drive consists of a flexible rubber belt stretched from a wheel below the turntable to a *stepped* pulley. This pulley has two separate diameters. It is attached to the shaft of an electric motor. The speed of the motor remains constant, and the speed of the turntable's rotation is changed by raising or lowering a forklike mechanism. This action causes the belt to become engaged with different diameters of the pulley.

In a direct drive system, the turntable is mounted directly on the motor shaft. The speed of the motor, which can be varied, determines the speed of the turntable's rotation. The motor's speed is controlled by a device called a *quartz crystal oscillator.*

The stylus is a piece of diamond or extremely hard synthetic material shaped somewhat like a cone. It is suspended from one end of a flexible strip of metal. The other end of the metal strip is attached to the cartridge.

The stylus vibrates as it rides in the groove of a record. In a stereophonic record player, the stylus responds to two separate sets of waves—one on either side of the groove. These two sets of waves correspond to the two stereo sound channels.

The cartridge receives vibrations from the stylus and transforms them into electric energy. Some car-

A standard record player includes such features as a turntable, a tone arm, and a *stylus* (needle). Record players are used widely to play recorded music for listening and dancing.

A compact disc player produces sound of better quality than that of a standard record player. Compact discs and compact disc players first appeared on the market in the early 1980's.

tridges have ceramic or crystal bars that generate weak voltages when twisted (see **Piezoelectricity**). The sideways movement of the stylus in the record groove twists these bars, causing them to produce electric signals that correspond to the waves in the groove. A more commonly used type of cartridge generates voltages when the stylus moves an electric coil in a magnetic field or moves a magnet near a coil. A stereophonic cartridge transforms the stylus vibrations into two separate sets of electric signals—one for the right sound channel and the other for the left.

The tone arm, also called the pickup arm, holds the cartridge and stylus. Some record players are equipped with a *linear tracking* tone arm, which moves in a straight line across the record. But in most record players, the tone arm is mounted on a pivot. The pivot lets the stylus ride the record groove in an arc across the disc. The pressure of the stylus is controlled by a weight at the pivot end of the tone arm. Too much pressure causes poor sound quality and increased record wear. If there is too little pressure, the stylus will skip across the record. Wires along the tone arm carry electric signals from the cartridge to the amplifier.

The amplifier boosts the power of the weak signals from the cartridge so that they reach the speakers in sufficient strength. The speakers convert the electric signals to sound waves (see **Speaker**).

How gramophone records are made

Most gramophone records made today are thin plastic discs with diameter of 18 or 30 centimetres. An 18-centimetre record is played at a speed of 45 rpm and has only a few minutes of sound per side. A 30-centimetre *long-playing* (LP) record is played at $33\frac{1}{3}$ rpm and holds about 30 minutes of sound per side. For a description of compact discs and their manufacture, see the section *Digital sound recording and reproduction.*

The main steps in making a standard gramophone record are (1) making the master tape, (2) editing the master tape, (3) transferring the recording to a disc, (4) preparing the record moulds, and (5) making the finished copies.

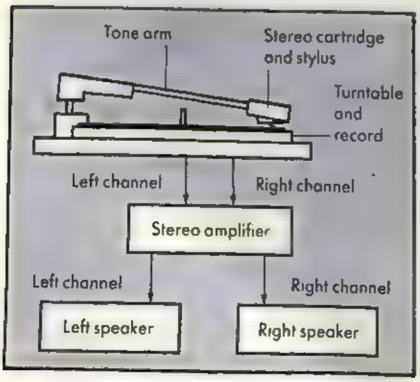
Making the master tape. The production of most records begins with making a *master* (original) tape recording in a soundproof studio or in a concert hall. Such recordings are made using tape recorders capable of recording 8, 16, 24, or 32 separate channels, or *tracks* (see **Tape recorder**).

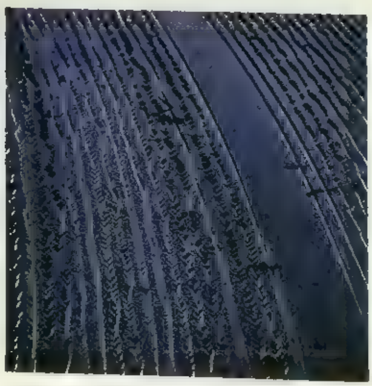
In producing the master tape, different instruments or groups of instruments are recorded on separate tracks. During recording, various aspects of sound quality can be controlled separately for each track. In addition, each track can be recorded and played back alone or in combination with other tracks. For example, if one musician makes a mistake, his or her track can be recorded again separately without the other musicians having to repeat their performance. The musician simply performs the part again while listening on headphones to the tracks recorded by the other musicians.

Editing the master tape. Often, several *takes* (separate recordings) of a piece of music are made at a recording session. But no single take may be entirely acceptable. In such cases, the best performance of each section of music is chosen from among the different takes. Then, a recording engineer *edits* (rearranges) the sections electronically. This editing results in the creation of a new master tape with the sections from different takes arranged as though they had been recorded in a single performance. The new master tape may still consist of many separate tracks. In such cases, a process called *mixdown* may be used to combine tracks to reduce their number to the two needed for a stereophonic disc.

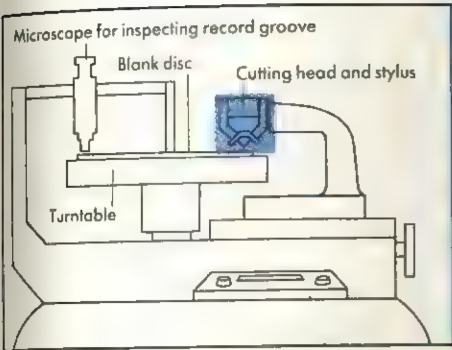
Transferring the recording to a disc. The next step in making a gramophone record is the creation of a *master lacquer.* A lacquer is an aluminium disc coated with acetate, plastic, lacquer, or a combination of these substances. The production of a master lacquer involves rotating a blank lacquer on the turntable of a machine called a *record-cutting lathe.* Electric signals from the master tape are fed to a *cutting head* on the lathe in order to transfer these signals to the lacquer. A *cutting stylus* on the cutting head cuts a wavy, V-shaped groove that spirals toward the centre of the disc. This stylus is connected to two electric coils, each near a separate electromagnet.

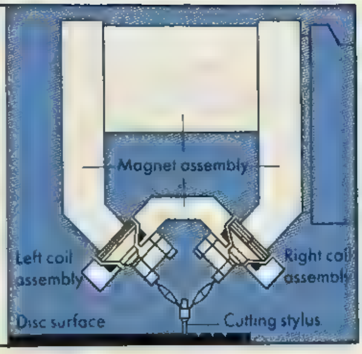
In making a stereo lacquer, electric signals corresponding to the right channel magnetize one coil. Those corresponding to the left channel magnetize the other coil. The electromagnets are placed so that the magnetic changes in the coils cause the stylus to move up and down and from side to side. This movement enables the stylus to cut a different wave pattern on either side of the groove. The waves for the left channel are cut on one side of the groove and those for the right channel are cut on the other.





A stereophonic record player, *far left,* reproduces two sound channels from a single record groove. The stylus rides in the groove of a record. A photograph of the magnified grooves on a record, *left,* shows the waves that make the stylus vibrate. The cartridge changes the vibrations into two sets of electric signals. The amplifier strengthens the signals, and the speakers turn them into sound.





Cutting an original disc is done on a cutting lathe, *far left.* The stylus in the cutting head cuts a groove in a blank disc revolving on the turntable. A stereo cutting head, *left,* has two coil assemblies that are magnetized separately by electric signals from each channel on a master tape recording. These magnetic changes move the stylus so that it cuts a groove with waves for both channels.

Loud sounds cause the stylus to cut deep, wide sections of groove. Quiet sounds cause it to cut shallow, narrow sections. If a section of groove is cut too close to the section cut on the previous revolution of the lacquer, poor sound quality results. This problem is avoided by using a computer that analyses the signals from the master tape as the lacquer is cut. The computer guides the record-cutting lathe and the stylus so that the coils of groove are cut as close together as possible without causing neighbouring sections of groove to interfere with each other. Cutting the coils of groove as close together as possible enables the disc to hold the maximum amount of recorded sound per side.

Preparing the record moulds. Next, a *metal master* is made from the master lacquer by a process called *electroplating* (see **Electroplating**). In this process, the surface of the master lacquer is coated with a layer of nickel. When separated from the lacquer, this nickel plate forms a *metal master*—a negative copy that has ridges where the lacquer has grooves.

Plating the metal master results in the formation of a *mother*—a positive copy of the lacquer. The mother itself is then plated several times in succession to create multiple negative copies called *stampers.* The stampers are used to make the finished plastic discs.

Making the finished copies. Two stampers, one for each side of the disc, are mounted in a hydraulic press. A blob of plastic, called a *biscuit,* is placed between the stampers and squeezed in the press. Steam circulating through the press softens the plastic, which is imprinted with record grooves from both stampers.

After the plastic is imprinted, cool water running through the press stiffens the disc. The disc is then removed from the press. The entire pressing operation takes a minute or less.

Digital sound recording and reproduction

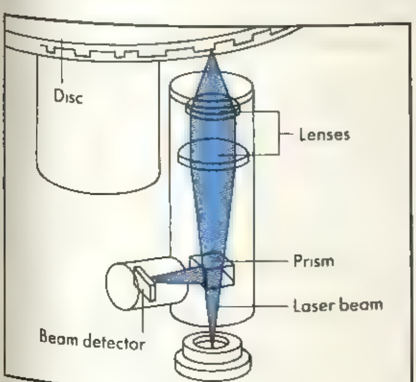
Compact discs, which appeared on the market in the early 1980's, produce sound of better quality than that of standard gromophone records. The first step in producing a compact disc is making a digital master tape. Such a tape is made by taking samples of sound 44,100 times a second, converting them into digital code, and then recording the code on the master tape.

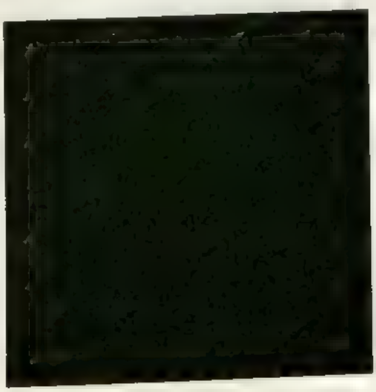
Sometimes, digital master tapes are used to produce standard gramophone records. But when a digital master tape is used to make a compact disc, the tape signal is fed to a powerful laser. Pulses of strong light from the laser cut billions of microscopic pits in the surface of a revolving blank master disc.

The master disc is used to form a stamper. The stamper impresses the pits on one side of a clear plastic disc. After the plastic disc has been stamped, it is then plated with aluminium and coated with a protective layer of clear plastic.

Compact discs measure about 12 centimetres in diameter. They have only one playing side, which can hold more than an hour of recorded sound. A laser in the compact disc player produces a weak beam of concentrated light that follows the spiral track of pits from the centre to the edge of the disc.

As the laser beam is reflected from the spinning disc, the pits break the beam up into a pattern of pulses of light. These pulses of light are then converted into electric signals. These signals are decoded and amplified by electronic devices before they are sent to the speakers.





A compact disc player, *far left,* uses a beam of concentrated light from a laser to reproduce sound. Lenses focus the beam on the spinning disc. Sound information is stored on the disc in a *digital* (numerical) code. The code takes the form of tiny pits and flat areas, *left,* that reflect light at different intensities. A prism sends the reflected light to a beam detector that changes the patterns of light into electric signals.

History

The first practical sound recording device was invented in 1877 by the U.S. inventor Thomas A. Edison. Edison's device could record sound on a small metal cylinder wrapped in tin foil, and then play the sound back. The cylinder rotated on an axle. A needle attached to a *diaphragm* (vibrating disc) was placed against the cylinder. As someone spoke into a mouthpiece, the sound waves made the diaphragm and needle vibrate. These vibrations caused the needle to make dents in the foil on the rotating cylinder. In order to play back the sound, another needle attached to a diaphragm was placed against the cylinder. As the cylinder was rotated, the dents in the foil made the needle and diaphragm vibrate. These vibrations created sounds roughly like the original sound.

In 1885, the U.S. scientists Chichester Bell and Charles S. Tainter improved upon Edison's invention by recording on cardboard cylinders coated with wax. This new recording material produced better sound.

In 1887, Emile Berliner, a German immigrant to the United States, invented the Gramophone—a recording device that used shellac discs instead of cylinders. These discs had better sound, were more durable, and could be mass-produced more easily than could cylinders.

The first electrically recorded gramophone records appeared in 1925. Manufacturers also began producing record players with electric motors and amplifiers, which greatly improved the quality of recorded sound.

Until 1948, all commercial disc recordings were made of a mixture of clay and shellac and were played at 78 rpm. In that year, the plastic $33\frac{1}{3}$ rpm LP record appeared on the market. It had been developed in the United States at the Columbia Broadcasting System Laboratories under the direction of Peter Goldmark, a U.S. electrical engineer. The LP held much more recorded sound and was more durable than the 78-rpm disc. In 1949, the 45-rpm disc was introduced by Radio Corporation of America (now RCA Corporation) to compete with the LP.

Growing interest in high fidelity in recorded sound led to the appearance of stereophonic record players and discs in 1958. Previously, records and record players were *monaural,* or monophonic. Such records and record players reproduce sounds from only one channel. By the late 1960's, almost all new record players and records were stereophonic.

During the 1970's, Thomas G. Stockham, Jr., a U.S. electrical engineer, developed digital recording. Compact discs and compact disc players appeared on the market in 1983.

Related articles in *World Book* include:

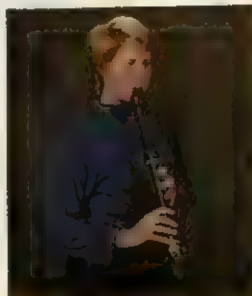
Berliner, Emile	High-fidelity system
Edison, Thomas A.	Recording industry
Headphones	Speaker

Recorder, in English law, generally refers to a part-time judge of the crown court in England and Wales. Recorders are chosen by the lord chancellor, and are barristers or solicitors who have had at least 10 years experience. In Northern Ireland, recorders are the judges of the county courts at Belfast and at Derry.

Until 1971, recorders in England and Wales were judges in the quarter sessions of a number of boroughs. Quarter session courts were abolished by the Courts Act of 1971.

See also **Court.**

Recorder is a type of flute that has a whistle mouthpiece. The instrument consists of a wooden or plastic tube with a row of seven finger holes and a thumb hole. A recorder is held almost vertically, and the holes are covered or uncovered to play different notes. The instrument has a soft, reedy tone. The most popular sizes are, from smallest to largest, soprano, alto, tenor, and bass.



A recorder has a whistle mouthpiece and holes that the musician covers and uncovers to play different notes. The instrument produces a soft, reedy tone. Tenor recorders, shown here, are among the largest of these instruments.

Tenor recorder

The recorder was invented during the Middle Ages and has remained basically unchanged. It became popular during the 1500's and 1600's and was an important part of the music of the Renaissance. By the mid-1700's, the modern flute had largely replaced the recorder. Since about 1920, however, a revival of interest has developed in the recorder and in recorder music of the Renaissance and baroque periods of music history.

See also **Wales** (picture: A love for music).

Recording industry is the group of businesses involved in the production and sale of records, cassette tapes, and compact discs (CD's). Hundreds of companies in the United States, and many more in other countries, make up the recording industry.

Making a recording

Each year, recordings are made in a wide variety of musical styles, including classical, country and western, jazz, blues, and rock. A number of spoken-word recordings, such as instructional records, comedy albums, and dramatic readings, are also made and sold. The procedure used to make these recordings varies. Weeks or months of preparation may be required before an orchestra is ready to record a piece of classical music. But performers may record a jazz album without any discussion except which songs will be played. This section deals primarily with how a popular recording is made.

Before recording. Performers who do not write their own music obtain a composition from a composer.

The recording industry makes and sells millions of records, tapes, and compact discs annually. Record stores, such as the one shown at the left, offer recordings in a wide variety of musical styles, including classical, blues, and jazz.

Composers protect their interest in a song by copyrighting it and by assigning it to a publisher (see **Copyright**). The publisher represents the song for the composer, and attempts to sell the song in printed form, to have it recorded, or to have it used in a film sound track or in other ways.

After an artist has decided to record a song, a copy of it is given to an arranger. The arranger adds instrumental or vocal parts, changing the music to suit the artist's performing style. An *artist and repertoire* (A & R) executive, who works for the record company, oversees artists and their recordings. The responsibilities of an A & R executive also include listening to demonstration, or "demo," tapes from new artists, deciding which artists to hire, and choosing which songs to record.

In a recording studio. A recording session involves the work of musicians, technicians, and assistants. They are directed by the session engineer and the producer. The engineer oversees all technical aspects of the recording session. For example, the engineer chooses the recording equipment and arranges the placement of microphones.

Most popular songs are recorded part by part. The singers and the drummer, guitarists, and other instrumentalists are recorded with separate microphones, and they are often recorded at different times. The engineer then *mixes* (combines on tape) the parts into a single performance. In this way, the engineer can control the overall sound of the song by correcting mistakes in the recording and by erasing unnecessary or undesirable parts.

The producer deals with all nontechnical aspects of the recording session. The producer's responsibilities include reserving the studio, hiring musicians, and keeping track of how much money each musician is paid.

In addition to session engineers, there are engineers who specialize in *mastering* and *remixing* the tape after the recording session. The mastering engineer prepares a tape of the song for transfer to the master stamper used in making the record (see **Record player** [How records are made]). This engineer tries to find an overall sound that will work best on most record players. Remix engineers work with tapes that are already mastered, adding new parts, or taking a section out, to make a slightly different version of the recording. Recording companies often remix popular recordings to try to make them more danceable.

Live recording involves installing portable recording equipment at a concert site. The engineer for such a recording tries to find the best way to set up the microphones so that the recording sounds as much as possible like the original performance. On some live recordings, even audience noise and the tuning of instruments between songs can be heard.

Few live recordings are made today. Such recordings do not have the excellent sound quality of those made in studios, where an engineer can carefully piece together a performance.

Releasing the recording. In general, a company can release a recording for sale whenever it wishes. Sometimes a company reissues an old recording because the public seems interested in it again. Or a recording may become unavailable because the company feels it can no longer make money selling it.

Major record companies have their own warehouses and sales offices. Sales personnel make sure that record stores and radio stations have copies of the song.

An artist receives a *royalty* from the record company for every recording sold. A royalty is a percentage of the price of the recording. For new artists, the royalty rate may be less than 5 per cent of the price. An established performer who is able to sell millions of records may command a much higher royalty rate.

Composers and publishers receive *mechanical royalties* for allowing a song to be recorded. These royalties are small and paid for each recording sold. In addition, the owner of the song's copyright receives a *performance royalty* whenever the music is used on radio or television.

The sale of *pirated* recordings loses recording companies and artists large sums of money annually. Pirated products include *bootleg* records made by secretly recording a live performance and records and tapes copied from an original recording without the recording company's permission.

Making a recording requires the skills of many people. A composer and an arranger, *above,* prepare the music for the musicians. Each part is then recorded separately by an engineer, *right.* The engineer later combines the parts into a final version.

Recording industry awards

Several organizations present awards for artistic and commercial achievement within the recording industry. For example, Grammy Awards are given annually by the American National Academy of Recording Arts and Sciences for artistic achievement in a broad range of categories. These awards include Artist of the Year and Record of the Year. Grammy winners are determined by members of the academy, which includes musicians, engineers, and producers.

The Recording Industry Association of America (RIAA) presents awards to artists who sell a specific number of records. When 500,000 copies of an album have been sold, an artist receives a *gold record.* A *platinum record* is awarded when sales of an album reach 1 million copies, and a *multi-platinum record* is given for sales of 2 million or more.

History

The history of the recording industry has been dictated by technological developments. In 1877, a U.S. inventor, Thomas Edison, invented the phonograph, which could record and play back sounds on tin-wrapped cylinders. By the late 1890's, the flat record had been introduced by the Victor Talking Machine Company of Camden, New Jersey, U.S.A. At first, records were played on only one side. During the mid-1920's, two-sided discs became widespread, and cylinder recordings began to disappear.

After World War I ended in 1918, records became a popular form of home entertainment. During the 1940's, recording tape was invented. As a result, the length of recordings was no longer determined by the wax blanks of three or four minutes duration that were being used at the time. The long-playing (LP) record was then introduced. Stereo records and recorded tapes were first sold during the 1950's and 1960's.

During the early 1980's, the compact disc was developed. A CD is a recording that is played back by laser beam, rather than with a needle. Because there is no physical contact between the beam and the disc, the disc does not wear out and there is no distortion of the sound.

See also **Copyright; High-fidelity system; Popular music; Record player; Tape recorder.**

Recording machine. See **Dictating machine; Record player; Tape recorder.**

Recreation is any activity that people voluntarily pursue for personal enjoyment, relaxation, or personal satisfaction, usually during their leisure, or spare time. People generally need to take part in some form of recreation as a break from the routine of a job or from school work. Recreation takes many different forms and occurs in many different places, depending on the choice of the individual. Some recreation is passive, such as watching television or listening to music. Participatory forms of recreation include singing in a choir or acting in an amateur dramatic society. Many people enjoy extremely active forms of recreation, such as hill-walking or playing various sports.

Since the end of World War II in 1945, recreation has gained an increasing amount of importance in modern life, particularly in industrialized countries. Increasingly higher incomes and improvements in working conditions and transportation have given many people more money, time, and mobility for recreation. Between the 1960's and the 1990's, the increased use in industry of automatic machines such as computers, as well as the effects of occasional economic recession, have reduced working hours. This has increased the importance and value of recreational facilities as a community resource for unemployed people.

Today, providing facilities for recreation, or leisure, is a major industry. Millions of people spend large amounts of money on recreational activities every year. Many companies operate in a number of countries providing facilities and equipment for commercial recreational use. Popular facilities include cinemas, bowling alleys, campsites, holiday resorts (including amusement arcades and funfairs), golf courses, squash and tennis courts, and theme parks. National parks offer a range of

recreational activities, from scenic walks to well-organized local heritage centres. A number of companies manufacture recreational merchandise such as sports equipment and camping supplies. Trade companies make various types of equipment, from soft drink machines to computerized arcade game machines.

Recreation provides pleasure for millions of people, but it may also make an important contribution to an individual's mental and physical health. For example, hospitals often organize recreational activities under trained supervisors as therapy for patients.

Kinds of recreation. The most popular single form of recreation is watching television. In developed countries, people watch 25 to 30 hours of television a week. The use of home video cassette recorders has let people extend their viewing hours.

Hobbies, such as gardening, stamp collecting, or home computing, provide recreation for many people. Other common types of recreation include games such as chess and bridge. Open-air forms of recreation, apart from gardening, include visiting a zoo or aquarium, picnicking, driving for pleasure, walking or jogging, watching or playing sports, bird-watching, camping, fishing, hunting, shooting, skiing, sailing, and taking nature walks. Other recreations include swimming and attending keep-fit or yoga classes. Every year, many people take a holiday, either at home or abroad.

Cultural activities such as going to concerts or theatre performances, or visiting museums, art galleries and exhibitions, provide recreation for millions of people around the world. Many people also find recreation in freely donating their spare time to voluntary work, such as helping charities, prison visiting, or working for a local church or other religious organization.

Opportunities for recreation. Private businesses, service organizations, and government agencies all provide opportunities and facilities for recreation. Some companies maintain sportsgrounds, swimming pools, or other facilities for their employees. Youth clubs, scout and guide organizations, and religious groups all provide recreational opportunities in the local community.

In many countries, the central government supports museums, national parks, and similar establishments. Most local government authorities have a recreation or parks department for maintaining facilities. Such departments are financed out of taxes and through fees or subscriptions. In some countries, local authorities have transferred their recreational services to private firms. Most military bases provide recreational facilities for members of the armed forces and their dependants.

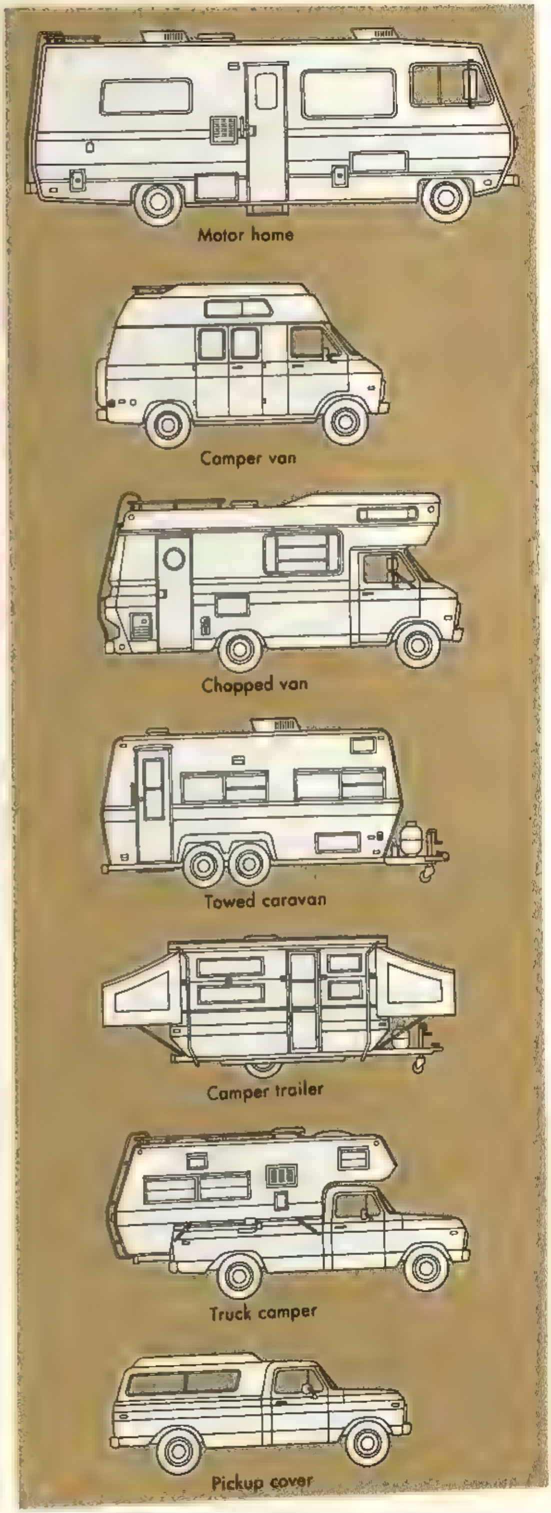
Related articles in *World Book.* See **Sports** and its list of *Related articles.* Other related articles include:

Camping	Hobby	Safety (Safety in recreation)
Carnival	Jogging	Storytelling
Circus	Museum	Television
Dancing	National Parks	Theatre
Electronic game	Park	Toy
Fair	Photography	Trampoline
Film industry	Play	World's fair
Game	Radio	Youth hostel
Handicraft	Reading	Zoo

Recreational vehicle (RV) provides temporary living quarters for people who are camping or travelling on holiday. Some recreational vehicles have an engine

Popular recreational vehicles

Recreational vehicles provide living quarters for people who are camping or travelling. Many models have a bathroom, kitchen, areas for sleeping, and other facilities of permanent homes.



and can be driven. Others are towed by cars. Still others are carried on trucks. All can be moved easily and can travel almost anywhere on land.

Recreational vehicles came into wide use during the 1960's. In the 1970's, the high cost of petrol made large vehicles expensive to operate. As a result, manufacturers began to build smaller units that use less fuel.

There are five types of recreational vehicles: (1) motor caravans, also called campers or motor homes, (2) towed caravans, or trailers, (3) camper trailers, (4) truck campers, and (5) pickup covers.

Motor caravans, also called *campers* or *motor homes,* are wheeled vehicles that have an engine and provide both transportation and temporary living quarters. They contain many conveniences found in permanent homes, including a bathroom or shower area, toilet, kitchen, and areas for eating and sleeping. They have a heating unit, refrigerator, and cooker, that operate on liquid gas. A storage tank carries water for washing and cooking. Another tank holds waste water and sewage. Most motor homes have tables and couches that can be converted into four to six beds.

The largest motor homes range from 5 to 11 metres long and measure about 2.3 metres wide. Smaller motor homes include *camper vans* and *chopped vans.* A camper van is a vehicle with its interior converted into living quarters. Most campers have a higher roof than standard vans. A chopped van is built on the frame of a van. It looks like a van with its cargo area "chopped off" and replaced by the body of a motor home.

Towed caravans or *trailers* have the same conveniences as motor homes but must be pulled by a car or truck. The caravan may be detached from the towing vehicle, which can be used independently. A towed caravan has two or four wheels, depending on its size. Some caravans are bigger than the largest motor homes.

Camper trailers are smaller and more compact than towed caravans. A camper trailer has collapsible sides of canvas, plastic, or some other material and can be folded into a boxlike shape for towing. The trailer provides a tentlike dwelling with sleeping space for as many as eight people. Some trailers have living quarters that are as completely equipped as those of caravans and motor homes.

Truck campers are also known as *slide-ons* and *toppers.* The living quarters section slides into the cargo area of a pickup truck or utility vehicle. They range from 2 to 5 metres long and are attached to the truck by bolts, clamps, and other fasteners. Truck campers have up to three beds and many of the other conveniences provided by larger recreational vehicles.

Pickup covers or *canopies* are portable units that enclose the cargo area of a pickup truck or utility vehicle. The enclosed space can be used as sleeping quarters for several people. Most of these vehicles have doors, insulation, lighting, and windows, but they lack a cooker, refrigerator, and toilet.

Rectangle is a four-sided plane figure with four right angles. A blackboard illustrates a rectangle. It is a parallelogram with right angles. Its opposite sides are parallel and equal. If all four sides are equal, the rectangle is a square.

The formula for the area (A) of a rectangle which is l units long and w units wide is $A = lw$. Its perimeter, P, is given by the formula $P = 2l + 2w$, or $P = 2(l + w)$.

If a room measures 12 metres by 15 metres, its floor area is 12 metres × 15 metres or 180 square metres,

Both (A) and (B) are rectangles, although (B) is ordinarily called a square.

and its picture moulding, or perimeter, is 2(12 + 15) or 54 metres.

See also **Quadrilateral.**

Rectifier. See **Electronics** (Switching; table: Terms).

Rectum. See **Alimentary canal; Colon.**

Recycling is the processing of wastes to recover materials that can be reused. Commonly recycled wastes include aluminium and steel cans, glass containers, and paper. Recycling helps conserve natural resources that otherwise would be used by manufacturers. It also helps reduce the pollution that may result from the disposal of various waste materials.

Recycling has been an important source of materials for the iron and steel industry and for paper manufacturers since the early 1900's. A growing concern over the dwindling supply of natural resources and the increase in environmental pollution has led to renewed emphasis on recycling since the late 1960's.

Recycled wastes provide materials for a variety of products. Manufacturers use aluminium from recycled cans to make new cans and various other metal products. Recycled paper is used not only in making paper but also in manufacturing such building materials as insulation, plasterboard, and roofing. Manufacturers grind up waste glass and use it in making new glass containers and some roadbuilding materials. Recycled motor oil can be used as industrial fuel oil.

Many communities have established *recycling centres* for the collection of recyclable wastes. Operators of the centres sort the wastes and send them to manufacturers who then make them into usable materials. Some recycling centres specialize in one type of waste, such as glass, metal cans, or paper.

Recycling centres collect a relatively small amount of reusable wastes. A greater amount by far remains mixed with other wastes that are discarded. These materials can be recovered only by special equipment that separates them from nonreusable wastes, such as food scraps. Engineers are working to develop recovery equipment that can process large amounts of wastes economically.

See also **Conservation** (Mineral conservation; picture); **Environmental pollution** (Controlling pollution); **Industry** (picture).

Red. See **Colour.**

Red Baron. See **War aces.**

Red blood cell. See **Blood.**

Red cedar. See **Juniper.**

Red Cross is an organization that works to relieve human suffering. More than 165 nations have Red Cross societies. Each national society carries on its own programme. But Red Cross workers in all parts of the world are united in their aims. They try to prevent misery in time of war or peace, and serve all peoples, regardless of race, nationality, or religion.

The name *Red Cross* comes from the organization's flag, which is a red cross on a white background. The flag honours Switzerland, where the Red Cross was founded in 1863. The Swiss flag is a white cross on a red field. Societies in most Muslim countries use a red crescent on a white field, and call themselves Red Crescent societies. In Israel, the symbol is a red Shield of David on a white field. See **Flag** (pictures: Flags of world organizations).

The International Red Cross

All Red Cross societies belong to the international Red Cross movement, made up of over 165 national Red Cross and Red Crescent societies in all parts of the world. Each society conducts humanitarian services according to its country's needs. All societies operate under the basic principles of Red Cross, and most carry on extensive medical and health programmes. Nearly all of the societies have junior divisions and youth activities.

National Red Cross societies cooperate internationally through their federation, the *League of Red Cross Societies,* which has headquarters in Geneva, Switzerland. The league encourages its members to work together, represents them in international discussions, and helps them develop their programmes. The *International Committee of the Red Cross,* also located in Geneva, serves as a neutral intermediary during conflicts between nations for the protection of war victims. It works for the continual improvement of the Geneva Conventions, the treaty that provides for the humane treatment of prisoners during war. It also grants recognition to new Red Cross societies. The League and the International Committee shared the 1963 Nobel Peace Prize.

The *International Red Cross Conference* is the highest deliberative body of the international Red Cross. Delegates from Red Cross groups and representatives of governments that signed the Geneva Conventions attend. The conference held every four years to discuss the Geneva Conventions and world humanitarian problems involving cooperation between the Red Cross and governments.

History

Beginnings. Jean Henri Dunant, a Swiss philanthropist, founded the international Red Cross. He was touring Italy in 1859 during the Austro-Sardinian War. Dunant saw the field at Solferino the day after 40,000 people had been killed or wounded in a battle. Horrified at the suffering of the wounded, he formed a group of volunteers to help them.

In 1862, Dunant published a pamphlet called *Un Souvenir de Solferino* (Recollections of Solferino). It ended with the plea, "Would it not be possible to found and organize in all civilized countries permanent societies of volunteers who in time of war would give help to the wounded without regard for their nationality?" The appeal won favourable response. On Oct. 26, 1863, delegates from 16 nations and several charitable organizations met in Geneva to discuss Dunant's idea. This conference laid the groundwork for the Red Cross movement and chose the organization's symbol.

The Red Cross in Bangladesh works in community health education to fight disease through the Child Alive programme.

Delegates from 12 European nations met in Geneva in August 1864, on invitation from the Swiss Federal Council. Out of this meeting came the *First Geneva* (or Red Cross) *Convention.* The 12 nations agreed to treat wounded soldiers as *neutral* (no longer taking part in the war), and to respect the neutrality of the Red Cross workers who looked after them.

Since the signing of the First Geneva Convention the International Committee of the Red Cross has worked to improve international humanitarian law. Four further Conventions were adopted in 1949. These were to protect sick and wounded servicemen on land and at sea, to protect victims of shipwreck, to work for the care of prisoners of war, and to protect civilians in time of war. The Red Cross works to protect all victims of war throughout the world. By 1988, 165 nations were signatories of the Geneva conventions.

The emblem. In 1864 the emblem of the Red Cross was chosen as a tribute to Switzerland. It was not intended to have any religious significance. In 1876, at the time of the Russo-Turkish war, the *Ottoman* (Turkish) *Society for the Relief of the Wounded* replaced the cross with a red crescent, an emblem which has since been taken up by most Muslim countries. The emblem of the red cross or crescent is used to protect the wounded and those who care for them. It is a breach of international law to use it to protect armed troops or weapon stores. It must never be used for commercial or publicity purposes.

Red Cross societies

In Australia and New Zealand, Red Cross societies are members of the League of Red Cross Societies. Their

The Red Cross works to relieve human suffering. During a fire, *far left,* a Red Cross volunteer helps a child to safety. Through the Red Cross disaster services programme, *left,* volunteers help provide food, clothing, shelter, and medical aid to disaster victims.

aims and activities, which coordinate with those of the International Red Cross, include voluntary community and social services. They provide emergency and disaster relief, blood transfusion services, and an enquiry and tracing bureau for missing persons.

The Australian Red Cross was established as a branch of the British Red Cross in 1914. It became an independent society recognized by the International Committee of the Red Cross in 1927. It has more than 89,000 adult members and 190,000 youth members.

In New Zealand the society was founded in 1917 as a branch of the British Red Cross. In 1931, it became an independent society recognized by the International Committee of the Red Cross. It was admitted to the league in 1932. It has nearly 89,000 adult members and more than 25,000 youth members.

In Britain, Red Cross volunteers carry out many services for sick, frail, elderly, and disabled people. For example, they help with holidays for handicapped children and escort disabled people on essential journeys. They also run clubs and day centres for the elderly. Trained members provide first-aid services at large public events. The British Red Cross Society (BRCS) trains members of the public in first-aid and nursing skills. The BRCS also provides a beauty care and cosmetic camouflage service.

In Canada, George S. Ryerson, an army doctor, founded the Red Cross movement. He first flew a flag with a red cross on a white background while serving in the Canadian Army Medical Services during the North West Rebellion of 1885. In 1896, Ryerson organized a Canadian branch of the British Red Cross. This branch developed into the Canadian Red Cross Society and was incorporated by an act of the Canadian Parliament in 1909. The International Committee of the Red Cross recognized the Canadian Red Cross in 1927.

In the United States, Congress did not ratify the Geneva Convention for 18 years, fearing foreign entanglements. The American Association for the Relief of Misery on the Battlefields was organized during this time. It adopted the red cross as its emblem. This group disbanded in 1871 because the United States had not yet ratified the Geneva Convention. Clara Barton worked to have the treaty ratified, and helped establish the American Association of the Red Cross in 1881. U.S. President Chester A. Arthur finally signed the treaty on Mar. 1, 1882. The U.S. Senate accepted it a few days later.

The work of the Red Cross and Red Crescent Societies

The societies are funded by voluntary contributions and by government grants. Much of their work is carried out by volunteers under the guidance of trained medical staff members. Since the founding of the societies, military medical services have improved and the work of volunteers is no longer essential on the battlefield. But the number of civilian victims of war has increased and it is among them that the work of the Red Cross has continued. The National Societies also work in first aid training, caring for the elderly and the handicapped, in public health care, and in rescue services. In some countries the societies are in charge of blood transfusion programmes.

Refugees. The National Societies give aid on an international level to assist refugees. As well as providing free medical attention, this service organizes food distribution, and provides shelter and clothing.

Disaster relief. After earthquake, flood, or hurricane disasters the National Societies send supplies and assistance to the striken areas. They also help to organize famine relief.

The Central Tracing Agency. At times of war, people move rapidly from the battle zones, may be taken prisoner, or killed. The Tracing Agency's main task is to record information of such cases which will help families to be reunited after major disasters. Its Geneva headquarters has the names of over 60 million missing people on its files.

Red deer is a large but graceful member of the deer family. The red deer is native to Europe, North Africa, and Asia Minor, and has been introduced to Australia and New Zealand. There are many subspecies. About 20 kinds of red deer live in the forests of Europe, Asia, and northern Africa.

Red deer eat grass, moss, and tender twigs. Their smooth coats range in colour from grey to yellowish-brown. All red deer have dark, shaggy collars and a yellow to orange patch on the buttocks. The *hart* (adult male) grows stately, branched antlers that are shed each year. A hart weighs from 110 to 160 kilograms, and stands 1 to 1.5 metres high. Most *hinds* (adult females) stand about 15 centimetres shorter than the harts, and have no antlers. They bear a single calf in late spring.

Scientific classification. The red deer belongs to the deer family, Cervidae. It is *Cervus elaphus.*

See also **Animal** (picture: Animals of the temperate forests); **Deer**; **Elk**.

Red fox. See **Fox**.
Red Guard. See **China** (The Cultural Revolution).
Red gum. See **Sweet gum**.
Red Legs. See **Greaves, Captain**.
Red panda. See **Panda** (with picture).
Red pepper. See **Capsicum**; **Cayenne pepper**.
Red poll. See **Cattle** (Red polls; picture).

Red River Rebellion, also called the First Riel Rebellion, occurred when the settlers in the Red River Valley of Manitoba, Canada, revolted against the Canadian government in 1869-1870. This uprising was called the Red River Rebellion. Most of the rebels were *métis* (people of mixed white and American Indian descent), who opposed the extension of British rule into a region that had long been almost independent.

The Hudson's Bay Company had ruled the Red River Valley until 1869. The company allowed the métis to live as they pleased. In 1869, however, the company turned its rights in Rupert's Land (including present-day Manitoba) over to the government of the United Kingdom (UK). In 1870, the UK gave the district to the Canadian government. The Canadian government produced plans for developing the region.

At this time, the only people who lived in the great Canadian Northwest were Indians, a few traders, and about 12,000 Red River Valley settlers. These settlers lived a simple life. They held no title to the lands they farmed. When they grew tired of a plot of ground, or if it proved unproductive, they moved on to some other spot which suited them.

The revolt. Road builders, surveyors, and officials of all kinds suddenly descended upon the settlers. Their lands had been arranged on the old French plan of strips reaching back from the riverfronts. The new officials decided to rearrange the farms into townships and sections. This alarmed and angered the settlers and caused great excitement.

A leader arose among the métis. He was Louis Riel, a settler of French, Irish, and Indian blood. The Canadian government soon sent out William McDougall as first governor of the new territory. When Riel heard of McDougall's approach, he determined to keep him from organizing the new government. Riel led the métis in an attack on Fort Garry, now the city of Winnipeg. They captured the fort, and Riel set up a "provisional government" there. The settlers prepared to resist the authority of the Canadian government. The métis met McDougall at the border of Rupert's Land and forced him to retreat.

McDougall wisely saw that the métis had a real grievance. He obeyed Riel in order to keep the peace. But at this point, Riel lost his head and doomed the rebellion. A group of loyalists made an attack on the métis at Fort Garry. The rebels drove the loyalists off and captured some of them. Riel imprisoned the captives as "enemies of the provisional government." A young English Canadian named Thomas Scott was one of those imprisoned. For some reason, the métis picked Scott as an example. They condemned him as a traitor to the provisional government and shot him.

Riel's flight. The people of eastern Canada became extremely indignant at this cold-blooded murder. A force of 700 men, under the command of Colonel Garnet Wolseley, was ordered into the Red River Valley. They made the long, difficult journey westward by way of Lake Superior. As they approached Fort Garry, Riel fled into the United States. His flight from the Red River Valley ended the rebellion.

While Wolseley and his men were marching westward, the Dominion parliament admitted Manitoba as a self-governing province of the Confederation. The government set aside 567,000 hectares of land for the use of the métis. But many of them were still dissatisfied and wandered westward into what is now Saskatchewan. Riel also appeared in that territory some years later, and led another revolt known as the Saskatchewan Rebellion. Riel was captured and hanged for treason in 1885.

See also **North West Rebellion.**

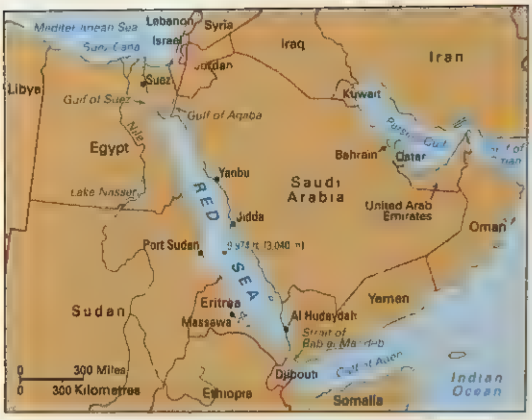
Red Sea is a long, narrow arm of the Indian Ocean that separates the Arabian Peninsula from northeastern Africa. The sea ranks as one of the world's busiest waterways. Much of the trade between Europe and Asia passes through the Red Sea, which is connected with the Mediterranean Sea by the Suez Canal.

Scholars are uncertain about the origin of the sea's name. One widely held theory is that the Red Sea is so named because a type of algae forms a reddish-brown scum on its surface during the summer.

The Red Sea covers about 456,000 square kilometres. The sea is about 2,200 kilometres long and about 350 kilometres wide at its widest point. Its average depth is 538 metres, but at its deepest point it is about 3,040 metres.

At its northern end, the Red Sea branches into the Gulf of Suez on the west and the Gulf of Aqaba on the east. The Sinai Peninsula lies between the two gulfs. The Gulf of Suez, a major offshore oil-producing area, leads into the Suez Canal. The Gulf of Aqaba leads to the Israeli port of Elat and the Jordanian port of Aqaba. At the southern end of the Red Sea, a narrow waterway called the Strait of Bab el Mandeb flows into the Gulf of Aden, which, in turn, leads into the Indian Ocean.

The Red Sea lies in the Great Rift Valley system, a series of valleys that cut through much of eastern Africa and part of southwestern Asia. High cliffs tower above both banks of the sea. In most places, narrow coastal plains lie between the cliffs and the sea. The Red Sea has large numbers of coral reefs. The reefs, together with irregular currents and strong winds, make navigation in the Red Sea difficult for small vessels.



Location of the Red Sea

In summer, the water temperature at the surface of the Red Sea averages 29 °C. The waters are among the saltiest in the world. Extreme heat in the region produces a rapid rate of evaporation, resulting in the high salt concentration. Some salt is collected in evaporation pans for local use. Many varieties of fish live in the Red Sea. But the number of fish of each variety is too small to make commercial fishing profitable.

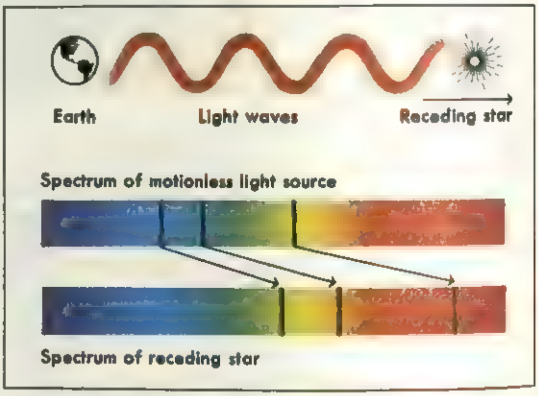
The Red Sea was probably formed millions of years ago when the Arabian Peninsula and the African continent drifted apart. A famous story in the Bible describes the parting of the waters of the Red Sea, which enabled the Israelites to escape from Egypt (Exod. 14). However, because the Hebrew text actually says "sea of reeds," most modern scholars believe that it refers to the marshy lands east of the Nile Delta, well to the north of the Red Sea. The Red Sea has served as an important trade route since ancient times. Before the opening of the Suez Canal in 1869, goods were transported overland by camel or donkey between the Mediterranean and Red seas.

Red shift is a shift in the wavelength of light emitted by a cosmic object toward the longer (red) wavelengths of the object's spectrum. Light acts like a wave, and its wavelength is the distance between crests of successive waves. The term *red shift* comes from the shifts first detected in wavelengths of light, but such shifts also occur at radio and other electromagnetic wavelengths. When a red shift occurs, all wavelengths are lengthened by the same fraction. A red shift is expressed as a percentage increase over the normal wavelength.

An example of a red shift can be seen in the spectra of *quasars,* extremely powerful sources of radio and light waves (see **Quasar**). A series of bright spectral lines caused by hydrogen appears in the spectrum of Quasar 3C 273 (Object 273 in the 3rd Cambridge catalogue of radio sources). The wavelength of each line of 3C 273 is 15.8 per cent longer than normal. Thus, the red shift of the quasar is 15.8 per cent.

Most astronomers believe that red shifts occur in cosmic objects because the earth and the objects are speeding away from each other. The shift in wavelength is caused by the Doppler effect (see **Doppler effect**). The amount of red shift of an object indicates its velocity. Objects with small red shifts move at a percentage of the speed of light equal to the red shift percentage. To calculate the velocity of objects that have larger red shifts, astronomers must take into account the effects of the special theory of relativity (see **Relativity** [Special theory of relativity]). The red shift of 3C 273 indicates a speed of 43,500 kilometres per second, which is 14.5 per cent of the speed of light. Some quasars have red shifts of more than 300 per cent, indicating that they have a speed of over 88 per cent of the speed of light.

In 1929, Edwin Hubble, an American astronomer, discovered that the red shift of galaxies increases uniformly with the increasing distance of the galaxies from the earth. Thus, the red shift could be used to estimate the distance of the galaxies from the earth. Hubble's discovery has led astronomers to believe that galaxies are rapidly moving away from one another as in an explosion. His findings form the basis for the theory that the universe is expanding.



Red shift is a shift in the spectral lines of a cosmic object toward the red end of the spectrum. Most astronomers believe red shifts occur in cosmic objects because the earth and the objects are speeding away from each other. The spectrum of a receding star, *above,* shows a red shift when compared with that of an object that is motionless relative to the earth.

See also **Astronomy** (Measuring distances in space; diagram: Detecting red shift and blue shift); **Astrophysics**; **Hubble, Edwin Powell**; **Light** (The visible spectrum).

Red Square. See **Moscow** (Famous landmarks; picture); **Russia** (picture).

Red tape is an unfavourable term used to describe the inefficiency of any large bureaucracy, public or private. The term originated in England during the 1700's. People used red string to tie legal and official documents together. Later, the term came to mean official routine in general. *Red tape* may describe an official's rigid observance of rules and regulations; the routing of requests and orders through channels, resulting in delay; or excessive paperwork. See also **Bureaucracy**.

Red tide is a term used for brownish or reddish areas of ocean, river, or lake water. The colour comes from microscopic organisms that have suddenly increased by the millions. The discoloured areas may range from a few square metres to over 2,500 square kilometres. They last from a few hours to several months. Red tides appear in waters in most parts of the world.

Most red tides are harmless. But some kill fish and other water animals, which then may float on the water

or wash ashore in great numbers. The decaying bodies cause an unpleasant odour. Still other red tides do not kill sea life, but they make the shellfish that feed on them poisonous to eat. Harmful red tides are caused by several species of *dinoflagellates* (one-celled organisms). Some dinoflagellates produce a poison that paralyses and kills fish. Dinoflagellates may also kill fish during red tides by using up nearly all the oxygen in the water.

Scientists do not fully understand why the dinoflagellate population suddenly increases, causing red tides. It is known that dinoflagellates accumulate when the nutrients, temperature, amount of sunlight, water currents, and other conditions in the water suit their needs. They may decrease when other sea creatures eat the food of the dinoflagellates. When many favourable conditions occur at the same time, the dinoflagellates have a "population explosion" and red tides occur.

See also **Dinoflagellate.**

Red-winged blackbird is the name of one of several species of New World blackbirds. The red-winged blackbird lives in North and Central America from the Rocky Mountains to the Atlantic Ocean. It grows to about 25 centimetres long.

The birds nest in bushes or small trees in swamps and marshes. They build their nests of dried grass, cattails, or reeds. The female lays from three to five eggs that are light blue or olive, with black, brown, or purple scrawls. The birds eat grain, but they also devour insects and weed seeds. The red-winged blackbird forms very large flocks outside the breeding season.

Scientific classification. The red-winged blackbird is in the New World blackbird family, Icteridae. It is *Agelaius phoeniceus.*

See also **Blackbird.**

Redback spider is a dangerous spider that is common in Australia. It is closely related to the *black widow spider* of the United States and the *katipo* of New Zealand. Male redbacks are small, inoffensive spiders, and are of no danger to human beings. The females, which are larger, have a glossy black body about the size of a pea and thin, black legs. A stripe, which may vary in colour from yellow-orange to scarlet, runs along the upper surface of their bodies.

People bitten by female spiders may become ill and suffer severe pain. Deaths from redback spider bite have been virtually eliminated since the development of an antivenin in the 1950's.

Scientific classification. The redback spider belongs to the family Theridiidae. It is *Latrodectus hasselti.*

See also **Black Widow.**

Redbreast. See **Robin.**

Redbridge (pop. 220,600) is a borough within the Greater London area, in England. It includes the former boroughs of Ilford, and Wanstead and Woodford, and parts of Chigwell and Dagenham. Redbridge is mainly residential. Industries in the district include light engineering and the production of telecommunications equipment.

Redditch (pop. 76,900) is a new town and local government district in Hereford and Worcester, England. Redditch was designated a new town in 1964. Workers in Redditch make needles, fishing tackle, metal springs, leather goods, soft drinks, and bathroom fittings. Engineering is an important activity. The Kingfisher Shopping Centre in Redditch is one of Britain's largest covered shopping areas. See also **Hereford and Worcester.**

Redfern, William (1778-1833), worked to gain full rights for *emancipists* (pardoned convicts) during the early days of settlement in New South Wales, Australia. In 1801, Redfern was transported to New South Wales for his part in the mutiny of Royal Navy ships at the Nore. In 1803, he received a full pardon. He worked for a time as a surgeon on Norfolk Island. He returned to Sydney in 1808. There, he was examined by naval surgeons to prove his competence as a doctor. He worked at Dawes Point Hospital, then became the doctor to governors William Bligh and Lachlan Macquarie.

William Redfern

Redfern became a close friend of Macquarie. Macquarie sent him to Britain with a petition regarding the position of the emancipists in New South Wales. After 1824, Redfern worked chiefly at farming. He was born in Wiltshire, England.

Redford, Robert (1937-), is an American film actor and director. Redford has played a wide variety of characters, especially talented, independent men. Redford won the 1980 Academy Award as best director for *Ordinary People.*

Charles Robert Redford, Jr., was born in Santa Monica, California. He made his acting debut on Broadway in 1959 and his film debut in *War Hunt* in 1962. Redford first won acclaim in 1963 in the Broadway comedy *Barefoot in the Park.* He also starred in the film version of this play in 1967. Redford established his box-office popularity with his performance as a Western outlaw in the film *Butch Cassidy and the Sundance Kid* (1969) and as a successful screenwriter in *The Way We Were* (1973).

Robert Redford

Redford has also starred in two political films, *The Candidate* (1972) and *All the President's Men* (1976). His other films include *Jeremiah Johnson* (1972), *The Sting* (1973), *The Great Gatsby* (1974), *Three Days of the Condor* (1975), *The Electric Horseman* (1979), *The Natural* (1984), *Out of Africa* (1985), *Legal Eagles* (1986) and *Havana* (1990).

Redgrave is the surname of three distinguished British actors—Sir Michael Redgrave and his daughters Vanessa and Lynn.

Sir Michael Redgrave (1908-1985) became known for his roles in *Hamlet* and other plays of William Shakespeare and also made more than 50 films.

Redgrave made his stage debut in 1934 in *Counsellor-*

at-Law. He began his film career in 1938 in *The Lady Vanishes,* a famous suspense film directed by Alfred Hitchcock. Redgrave's other films include *The Stars Look Down* (1939), *Dead of Night* (1945), *Fame Is the Spur* (1947), *The Browning Version* (1951), *The Importance of Being Earnest* (1951), and *The Loneliness of the Long Distance Runner* (1963).

Michael Scudamore Redgrave was born in Bristol and graduated from Cambridge University. He was knighted in 1959. He was married to Rachel Kempson, a famous stage actress.

Vanessa Redgrave (1937-) began acting in 1957. Her films include *Morgan—A Suitable Case for Treatment*; *Blow-Up*; *Camelot*; *Charge of the Light Brigade*; *The Trojan Women*; *The Devils*; *Mary, Queen of Scots*; *Agatha*; *My Body, My Child*; and *Wagner*. She won a 1977 Academy Award as best supporting actress for her performance in *Julia*. For many years, she took an active part in politics.

Lynn Redgrave (1943-) began her acting career in 1963. She took part in several contemporary stage works. Her films include *Tom Jones*, *Georgy Girl*, *The Virgin Soldiers*, *National Health*, *The Big Bus*, and *Sunday Lovers*. She has also had many television appearances. She now lives in the United States.

Redi, Francesco. See **Spontaneous generation; Life** (The theory of spontaneous generation).

Redmond, John Edward (1851-1918), an Irish leader, succeeded Charles Stewart Parnell as the political champion of Irish Home Rule. Redmond believed in moderation and was shocked by the bloody Easter Rebellion that took place in Dublin in 1916 (see **Ireland, History of**). The Sinn Féin Party, which approved of the use of violence to accomplish Home Rule, gradually displaced Redmond's party.

Redmond was born in Ballytrent, in County Wexford, and educated at Trinity College, Dublin. He first became a member of Parliament in 1881. See also **Parnell, Charles Stewart.**

Redpoll is a small bird related to the finches. There are two species, both from the Northern Hemisphere. The common redpoll is about 12 centimetres long. It breeds in open birch and conifer forest. Both male and female have a red crown, black chin, and whitish underparts, with dark streaks on the sides. In addition, the adult male has a rosy-pink breast. The Arctic redpoll is larger, about 15 centimetres long, with more white on the plumage. It breeds on the Arctic tundra. The breeding areas of the two species overlap. These birds build their nests in bushes or small trees. They construct them chiefly of grass stems and line them with feathers. The females lay from five to seven blue eggs speckled with reddish brown.

The redpoll, a member of the finch family, has a reddish crown. The adult male, *above,* has rosy-pink breast feathers.

Redpolls eat mostly plant food, and some insects. They feed on the flowers and seeds of willows, the buds of larch, and the seeds of alder and birch trees. They also take the seeds of smaller plants such as chickweed and willowherbs. In winter, redpolls commonly travel about in flocks.

Scientific classification. Redpolls are in the finch family, Fringillidae. The common redpoll is *Acanthis flammea,* and the Arctic redpoll is *A. hornemanni.*

Redshank is a wading bird of Europe and northern Asia. In the breeding season, both sexes have distinct white patches on the wing, barred black-and-white tail plumage, and the *bill* (beak) and legs are a bright orange-red.

The redshank breeds in marshes, wet grassland, or moorland. The nest is a hollow in the ground, generally at the base of a tussock of grass, lined with a large amount of dry grass. Both the eggs and young are well camouflaged. In the autumn, redshank migrate to milder coastal areas where they often congregate with other waders such as dunlin. Redshank feed by probing soft mud for invertebrate animals such as worms.

Scientific classification. The redshank belongs to the sandpiper family, Scolopacidae. It is *Tringa totanus.*

See also **Sandpiper.**

Redskin. See **Indian, American.**

Redstart is a woodland bird of Europe and North Africa. It grows to about 14 centimetres long. The male has a rust-coloured tail and chest, black face mask and white forehead. The female is brown above, with pale underparts but has the same rust tail as the male. The name redstart means *red tail,* and comes from the Anglo-Saxon word *stoert,* meaning tail. The redstart feeds on insects. It breeds in holes in trees or rocky crevices, generally in open oak woodland or parkland.

On the European continent, the *black redstart* breeds on rocky hillsides. In the United Kingdom after World War II (1939-1945), the black redstart used bombed buildings as nest sites. It often nests around factories and railway yards. There are also several species of Asian redstarts. The *American redstart* has similar colouring to the male common redstart but is not related.

Scientific classification. Redstarts belong to the thrush group Turdidae. The redstart is *Phoenicurus phoenicurus* and the black redstart is *P. ochruros.* The American redstart belongs to the wood warbler family Parulidae. It is *Setophaga ruticilla.*

Reduction is a chemical reaction in which a substance gains electrons. The term originally referred to any chemical process in which a substance either combines with hydrogen or loses oxygen.

Reduction is the opposite of *oxidation,* a chemical reaction in which a substance gives up electrons. Reduction and oxidation always occur together. These two combined reactions are known as *redox reactions.* See **Oxidation.**

Many kinds of processes involve reduction. For exam-

ple, metal plating occurs when metal ions in a solution are reduced to form neutral atoms. When a piece of copper is placed in a solution containing silver ions (Ag^+), it slowly becomes coated with silver. In this process, each positively charged silver ion gains an electron given up by a copper atom and becomes a silver atom. The chemical equation for the reduction of silver is written as follows:

$$Ag^+ + 1e^- \rightarrow Ag.$$

An example of the original meaning of reduction is the combining of nitrogen and hydrogen gases in the production of ammonia (NH_3). Another example is the removal of oxygen from zinc oxide (ZnO) to form metallic zinc. Zinc may be extracted from its ore in this manner.

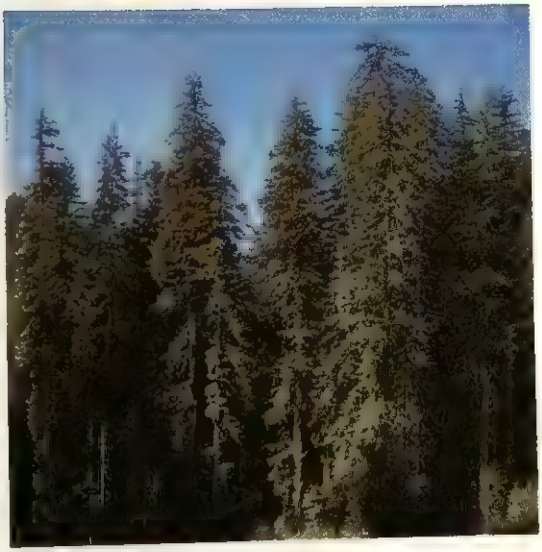
See also **Corrosion; Electrolysis.**

Redwood is a magnificent forest tree that grows along the West Coast of the United States from central California to southern Oregon. It thrives in the foggy climate along the sides of the mountains that face the Pacific Ocean, and only rarely occurs more than 80 kilometres inland. The redwood is also called *coast* or *California redwood* to distinguish it from the giant sequoia to which it is related (see **Sequoia**).

Redwoods are among the world's tallest living trees. They commonly grow to 60 to 85 metres high and often have trunks that are 2.5 to 4 metres in diameter. A redwood in northern California is the tallest known tree in the world. It is about 110 metres high.

In a typical redwood forest, the massive trees grow close together, shutting out most of the sunlight. There is little underbrush, for few plants can survive in the cool, dim atmosphere. Often tight circles of young redwoods surround old stumps, completely enclosing them. The lowest branches of old trees may be 25 to 30 metres above the ground. However, the lowest branches of the young redwoods grow all the way to ground level.

The massive trunk of a redwood dwarfs a curious sightseer, *above*. The trunk may measure up to 4 metres in diameter. Redwoods grow along the West Coast of the United States.



Redwoods are among the tallest trees. They commonly stand 60 to 85 metres tall, and they grow so close together that little sunlight reaches the forest floor.

The redwood tree has yellow-green needles that grow about 2.5 centimetres long and remain on the tree for several years. The fruit is a globe-shaped, scaly cone, also about 2.5 centimetres long. Tightly packed under each scale are several reddish-brown seeds. Each seed is about 2 millimetres long. It would take about 271,000 of these tiny seeds to weigh a kilogram.

Redwood bark may be 30 centimetres thick. Its fibrous texture gives it a deeply fissured appearance and makes it fire resistant. The wood is soft, red, and weak. However, it is also remarkably resistant to decay, disease, or insect enemies. Timber manufacturers prize the wood for outer or interior finish in buildings, and for other nonstructural uses when durability is important.

Great *burls* (lumps) often grow on trunks of older redwoods. These burls are highly valued for their beautiful grain and are often used for veneer. Small burls are sold for table decorations because of their ability to sprout when placed in water.

Many redwood forests have been set aside as state or national parks in order to preserve the ancient beauty of these impressive trees.

Scientific classification. The redwood belongs to the taxodium family, Taxodiaceae. It is classified as *Sequoia sempervirens.*

See also **Sequoia; Tree.**

Reed is a common name for four kinds of tall, slender grass plants. The word may also refer to the stems of these plants, which are often jointed in many places. The stems may be as slender and fragile as straw, or as thick and sturdy as bamboo. The pith that fills the centre of the reed can usually be removed, leaving a hollow, jointed tube. The hollow stems of the reed have been used to make musical instruments.

The reed musical instruments have a mouthpiece containing a vibrating strip that was once made only of reed. Plastic, wood, glass, and metal are now used to make the "reed." Farmers in Europe thatch their houses

with dried stems of the common reed. In India the leaves are used to make floor coverings called *durries*. In Japan, young reed shoots are eaten. The pulp of reeds is used to make paper and cardboard.

Reeds grow in almost all countries of the temperate and warm regions. They are found in a variety of habitats, from low upland meadows to wet lowlands and shallow lakes and ponds.

Many reeds grow in large areas called *reedbeds*. These are important breeding and nesting grounds for many birds. The delta of the Danube River, in Romania, has very large areas of reed bed.

Scientific classification. Reeds belong to the grass family Graminae (Poaceae). The common reed is *Phragmites communis*.

Reed, Sir Carol (1906-1976), directed many fine films, including *The Stars Look Down* (1939), *Odd Man Out* (1947), *The Fallen Idol* (1948), *The Third Man* (1949), and *Our Man in Havana* (1960). Reed was born in Putney, London. He worked first at Ealing Studios, directing his first film in 1936. He was knighted in 1952.

Reed, Walter (1851-1902), a medical officer in the United States Army, helped show how to control typhoid fever and yellow fever. During the Spanish-American War in 1898, he became chief of a commission to study the origin and spread of typhoid fever in Army camps. Experiments showed that flies were the most important carriers of the infection, and that dust and uncleanliness helped spread it.

In 1900, Reed headed a commission to investigate an epidemic of yellow fever among American troops in Cuba. He and other doctors carried out a series of daring experiments. Several of the doctors, as well as a number of soldiers, volunteered to be infected by yellow fever germs to study the course of the disease. All of them contracted the disease but survived. The experiments established that the bite of certain mosquitoes transmits yellow fever. They showed how the disease might be controlled. See **Yellow fever**.

Reed was born in Virginia, U.S.A. He studied medicine at the University of Virginia and at Bellevue Hospital Medical College in New York City. He entered the United States Army in 1875.

Reef. See **Atoll; Coral.**

Reel. See **Fishing** (Reels).

Rees, Dai (1913-1983), a Welsh former golf champion and Ryder Cup team captain, won most of the major golfing events. Rees was born at Barry, in South Glamorgan, Wales. He first played for the Ryder Cup team against the United States in 1937. In 1957, he captained a successful British Ryder Cup team.

Rees, Lloyd (1895-1988), an Australian artist, became known for his landscapes. Lloyd Frederic Rees was born in Brisbane, Queensland. He studied at the Brisbane Technical College and at the Chelsea Polytechnic, in London.

Reeve was the holder of one of two different official positions in medieval English society. The *king's reeve* was the administrator of a royal estate or manor before the Norman Conquest. In feudal times, a reeve was a minor official of a manor.

Reeve, the female ruff. See **Ruff.**

Reeves, Sir Paul (1932-), was governor general of New Zealand from 1985 to 1990. He was the first person of Maori descent to hold the office. He was born in Wellington, New Zealand. He became a deacon in the Anglican church in 1958. From 1971 to 1979, Reeves was bishop of Waiapu. He was then made bishop of Auckland. In 1980, at the age of 48, he became the youngest archbishop of New Zealand. He was also the first Maori to hold that position.

Reference book. See **Almanac; Atlas; Dictionary; Encyclopedia; Library; Publishing** (Reference books).

Referendum is a vote of the people on a question. It gives all the voters of a country or region a chance to vote on government policy or on a suggested new law. In a referendum voters show whether or not they approve of a proposal. A referendum is sometimes called a *plebiscite*.

Referendums are used in many countries. They can be on many types of issue, from changes in the constitution to the definition of national boundaries. The rules under which they operate vary considerably from country to country.

A referendum can be either *optional* or *obligatory*. In some countries, an optional referendum may be held to gain approval for legislation already passed, but then only if a specified number of voters demand it. An obligatory referendum is one in which the voters must approve a new law before it becomes valid.

The *initiative,* which is found largely in the United States, is a method whereby a group of citizens can put a legislative proposal before the electorate directly, to be decided in a referendum. The proposed law is initiated by the voters themselves. An individual or a group may put up the petition or proposal. If a specific number of voters supports the petition, a referendum must be held. Initiatives are used mainly by some states in the United States to decide local government matters. Some states also use the system of *recall,* by which the voters can call their representatives to account.

Referendums may be held to test public opinion on proposed constitutional reforms. This is obligatory in Australia and in European countries such as Ireland, France, and Switzerland. The government puts a simple outline of the proposed changes on each voting card and electors vote yes or no. Switzerland, where the first referendum was held in the 1500's, makes frequent use of such elections. In 1989, for example, nearly 2 million Swiss voted on a proposal to abolish the national army. More than 60 per cent opposed abolition.

In Ireland, in 1983, a controversial referendum approved a constitutional amendment to ban abortion. In 1986 a government proposal to end a 60-year constitutional ban on divorce was defeated by national referendum. In a referendum in 1987, the Irish people affirmed Ireland's commitment to the European Community. In 1992, a referendum in Denmark rejected new moves to centralize the working of the European Community.

Referendums are also held to approve changes in national boundaries or internal frontiers. During the 1930's, the League of Nations organized a series of votes to allow the people of Germany to decide how their country should be divided into states. In 1989, the population of the Philippines was asked to approve the creation of a new selfgoverning region in the south of the archipelago. The negative result was seen as a personal rebuff for the president, Corazon Aquino.

Some countries use referendums rarely. In the United Kingdom, for example, the government believes that a general election is sufficient mandate for most policies. Referendums have been held in the UK on only two occasions. The first, on membership of the European Community, was held in 1975. Referendums were held in Scotland and Wales in 1979 on the question of *devolution* (stronger local government). See **Devolution.**

Refining. See **Metallurgy** (Extractive metallurgy); **Petroleum** (Refining petroleum; diagram); **Sugar** (Making cane sugar).

Reflection is the return of a wave of energy, such as light, heat, sound, or radio, after it strikes a surface. Reflection can be compared to the action of a ball rebounding from a wall. A ball thrown at right angles to the wall will bounce back in the same line. If the ball is thrown along a path that makes less than a right angle with the wall, its path on rebounding will make the same angle with the wall, but on the opposite side of the point where the ball hit the wall. Imagine a line drawn to make a 90-degree angle with the wall at the point where the ball struck. The angle formed by the path of the thrown ball and this line is the *angle of incidence.* The corresponding angle made by the rebounding ball is the *angle of reflection.* These two angles are equal.

The principle of reflection has many applications in daily living. The mirror (a glass coated with silver) reflects most of the light that strikes it. Polished surfaces, such as chromium, reflect most of the light that strikes them. Clear transparent surfaces, such as window glass, reflect little light. The best example of the reflection of sound waves is the echo. Radar uses the reflection of radio waves.

See also **Light** (Reflection, refraction, and absorption); **Echo; Kaleidoscope; Mirror; Parabola; Radar; Sound** (Reflection); **Telescope.**

Reflex action is an automatic or involuntary movement provoked by a sensory stimulus, such as a pinprick on the skin. If you accidentally touch a hot stove, you jerk away before you have time to think what you are doing. Actions of this kind, which are not planned or decided beforehand, are called reflex actions. Each reflex involves some stimulus that causes an involuntary response. In the above example, the hot stove was the stimulus and the jerking away was the response.

Reflex actions are quite common and easy to notice. If light is directed at a person's eye, the pupil of the eye will *constrict* (become smaller). When the light is removed and the person's eye is shaded, the pupil becomes larger again. The light acts as a stimulus, and the reaction of the pupil is the eye's response. Doctors often test a person's reflex actions. Frequently they test the *patellar reflex,* or knee jerk. The patient sits with his knees crossed and the doctor strikes a point just below the kneecap. This causes the patient's foot to kick suddenly.

Scientists call these kinds of reflexes *unconditioned reflexes.* They occur in all normal persons and many animals. Unlike most human behaviour, unconditioned reflexes occur with no specific learning or experience. They are considered involuntary acts, because a response always occurs when a stimulus is presented.

How reflex action occurs. Most reflex acts are very complicated. But, in the simplest forms, four events are involved. Briefly, these could be called (1) reception, (2) conduction, (3) transmission, and (4) response. The stimulation is *received* by *receptors,* or sensitive nerve endings. These may be in the eye, ear, nose, tongue, or skin. Energy from the stimulus is changed into nerve impulses and *conducted* from the receptor to the central nervous system. From there, the nerve impulses are *transmitted* to the motor nerves, which control muscle action. The motor nerves conduct the impulses to the muscles and glands, causing them to *respond,* or act.

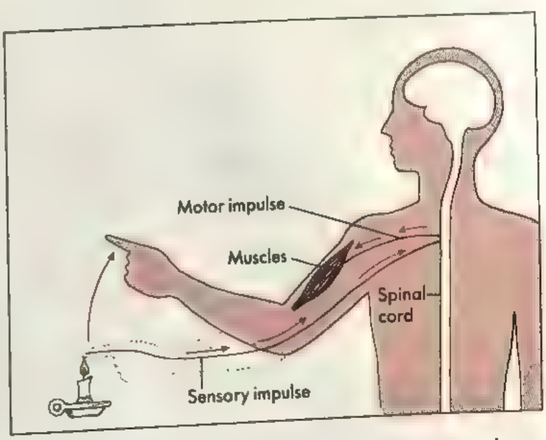
To illustrate the events in a reflex action, suppose a person touches the flame of a candle with his finger. The heat of the flame stimulates receptors in the skin of the finger. This creates a nerve impulse that travels along a sensory nerve to the spinal cord. In the spinal cord, the sensory nerve fibres interlace with motor nerve fibres. The nerve impulse passes from the sensory fibres to the motor fibres, which in turn relay it to the muscles, causing them to contract. When the muscles contract, the person's hand jerks back.

Most reflex acts are much more complicated than this. They often involve other parts of the nervous system, such as the brain. Reflex acts are quicker than voluntary acts. You jerk your hand away from a hot stove before you feel pain. You do not have to take the time to decide exactly what you are going to do.

People have many reflex reactions to emotional stimuli. These include changes in blood pressure and respiration. A lie detector measures certain body reactions to emotional stimuli. A person telling a lie usually has small emotional reactions that can be detected because of these reflex reactions. See **Lie detector.**

Conditioned reflex, another kind of reflex action, works by association. For example, a dog's mouth begins to water when the animal smells food. The Russian physiologist Ivan P. Pavlov (1849-1936) showed that the flow of saliva—though originally an automatic reaction to the smell of food—can become a conditioned reflex. Pavlov rang a bell each time he brought food to a dog. Eventually, the dog's mouth began to water when Pavlov merely rang the bell—with no food being present. The dog associated the ringing of the bell with the food, just as it associated the odour with the food.

See also **Nervous system.**



A reflex action occurs automatically. When a person touches a candle flame, impulses travel along a nerve to the spinal cord. The message is relayed to the muscles, which jerk the arm back.

Reforestation. See Conservation (Forest conservation); Forestry.

Reform acts. See United Kingdom, History of the (Age of development 1830-1906 [Political developments]).

Reform bills, in England. See Chartism; United Kingdom, History of the (The era of reform; Gladstone and Disraeli).

Reform school. See Reformatory.

Reformation was a religious movement of the 1500's that led to Protestantism. It had a tremendous impact on the social, political, and economic life of Europe, and its influences are still felt today. The movement began in 1517 when Martin Luther, a German monk, protested against certain practices of the Roman Catholic Church. About 40 years later, Protestantism was established in Europe.

Before the Reformation, Europe had been held together by the universalism of the Catholic Church and by the claim of the Holy Roman emperor to be the supreme *secular* (nonreligious) ruler. After the Reformation, Europe had several large Protestant churches and some smaller Protestant religious groups. All of them competed with the Catholic Church—and with each other—for the faith and allegiance of the people.

The sale of indulgences caused Martin Luther to attack the church. This picture shows church representatives selling indulgences. The pope's authorization for the sale hangs on a cross.

Causes of the Reformation

Religious causes. During the late Roman Empire and the early Middle Ages, missionaries had converted the peoples of Europe to Christianity. The pope gradually assumed greater importance and authority in the church and in relation to the secular rulers. In the early 1200's, Pope Innocent III claimed that "Ecclesiastical liberty is nowhere better preserved than where the Roman church has full power in temporal as well as spiritual matters." But about 100 years later, in 1303, King Philip IV of France humiliated Pope Boniface VIII by having him arrested (see **Philip** [Philip IV]). The secular rulers were growing in power.

In the 1300's and 1400's, the church suffered several serious setbacks. In 1309, a French pope, Clement V, moved the papacy from Rome to Avignon, France, where it remained for about 70 years. This period was called the *Babylonian Captivity,* in remembrance of the 70 years that the Biblical prophet Jeremiah predicted the Jews would spend as captives in ancient Babylon. In 1378, after Pope Gregory XI moved the papal residence back to Rome, a small group of cardinals elected another pope, called an *antipope* (see **Pope** [The troubles of the papacy]). For nearly 40 years, there were two or three popes at a time. This split caused great confusion in the church. Some Catholic leaders believed that the church should be ruled by church councils rather than by a pope. Such councils met in Pisa, Italy, in 1409; in Constance, Germany, from 1414 to 1418; and in Basel, Switzerland, from 1431 to 1449. The councils called for a "reform in head and members."

Serious abuses also had appeared in the church. The large administrative structure of the church required a great deal of money to finance it. To obtain this money, the church used many devices that hurt its spiritual nature. These devices included selling important positions

The Augsburg Confession summarized the religious teachings of Martin Luther. In this picture, the confession is being read to Charles V, Holy Roman Emperor, at the Diet of Augsburg in 1530.

in the church. In Italy, the popes and higher clergy lived like secular princes. They built lavish palaces and indulged in corrupt financial practices. The religious life of the church suffered. The sacraments were often celebrated meaninglessly, and the church's spiritual message about God's mercy was weakened by an emphasis on a person's good works. Such works included giving money to charity to earn salvation.

Critics of the church included the religious reformers John Wycliffe in England, John Hus in Bohemia, and Girolamo Savonarola in Italy. These men protested against the abuses but could not stop them. Some thinkers within the church, including Johannes Eckhart and Thomas à Kempis, emphasized a mystical approach to Christianity. But no one could restore the church's spiritual health and moral purity.

At the same time that the church was neglecting its spiritual leadership, a tremendous increase in religious feeling was developing among the common people in many parts of Europe. The situation created great tension between the common people and their church leaders in the 1300's and 1400's.

Cultural causes. Beginning in the 1300's, a great revival of learning and art called the Renaissance developed in Italy and, to a lesser extent, elsewhere in Europe. The Italian author Petrarch pioneered in the revival of classical studies—the literature, history, and philosophy of ancient Greece and Rome. Renaissance humanists believed that by returning to the classics, they could begin a new golden age of culture.

The interest in ancient civilizations encouraged by the Renaissance had an important effect on religion. The study of Hebrew and Greek enabled scholars to read the Holy Scriptures in the languages in which they originally had been written. Also, in studying early Christian times, scholars saw how the church had changed through the centuries. The invention of movable type in the mid-1400's helped spread learning through printed books. As a result, an increasing number of people outside the clergy gained an education during the Renaissance and Reformation.

Political causes. During the Middle Ages, the Holy Roman emperor claimed to be the secular head of Christianity. Kings ranked beneath the emperor, followed by princes, dukes, and counts. But the broad authority of the emperor never really existed, and by the end of the Middle Ages, the empire consisted chiefly of the German territories of central Europe. Even there, the princes of a large number of areas were independent. An imperial *diet* (council), which consisted of representatives of the nobility and of the cities, helped the emperor govern.

In western Europe, the kings were increasing their power over their own people and against the pope and the emperor. The monarchies in England, France, and Spain were growing stronger, organizing their finances, and building their armies. Some people regarded the pope as a political leader of a foreign state and opposed his control and influence in their own countries. After the Reformation began, some monarchs broke completely away from the pope.

Economic causes. During the Middle Ages, Europe had an agricultural economy. Most people were peasants who lived in villages and tilled the soil with simple tools. Beginning in the 1100's, cities began to increase in size, especially in Italy and the Netherlands. Merchants traded woollen cloth, glassware, iron implements, and other manufactured goods for raw materials such as furs, wood, and wool. As the cities grew wealthy and independent, they threw off the control of local lords and prince-bishops. Many turned to the king or emperor for protection.

Development of the Reformation

Martin Luther. The Reformation began within the Catholic Church itself. On Oct. 31, 1517, Martin Luther, a monk and professor of theology, posted his Ninety-Five Theses on the door of the Castle Church in Wittenberg, Germany. The theses were a series of statements that attacked the sale of *indulgences* (pardon from some of the penalty for sins). Luther later criticized what he considered other abuses in the church.

Luther believed that people could be saved only through faith in Jesus Christ. His view of religion placed a person directly before God, trusting Him and relying on His forgiving grace. Luther taught that God *justifies* human beings. By that he meant that God makes them righteous through His kindness to them. This doctrine of justification by faith in Christ alone was the heart of Luther's belief. It contradicted the church's teaching of grace and good works as a way to salvation.

In January 1521, Pope Leo X excommunicated Luther and declared him a heretic. Emperor Charles V and members of the imperial diet ordered Luther to appear before the diet in Worms, Germany, in April. There, Luther was ordered to *recant* (take back) what he had said and written. Luther replied in a famous speech: "Unless I am convinced by the testimony of the Scriptures or by clear reason (for I do not trust either in the pope or in councils alone, since it is well known that they have often erred and contradicted themselves), I am bound by the Scriptures I have quoted and my conscience is captive to the Word of God. I cannot and I will not retract anything, since it is neither safe nor right to go against conscience. I cannot do otherwise."

In May 1521, the emperor signed the Edict of Worms, a document which declared Luther to be an outlaw whom anyone could kill without punishment. However, Frederick the Wise, Prince of Saxony, protected Luther. Luther continued to lead the Protestant movement until his death in 1546.

The word *Protestant* (one who protests) dates from the diet of Speyer, Germany, in 1529. There, princes who supported Luther protested the anti-Lutheran actions forced on them by the emperor and the Catholic nobility. In 1530, the Lutherans presented the *Augsburg Confession* to the diet of Augsburg, Germany. The main author of the confession was Philipp Melanchthon, Luther's chief colleague in the Reformation. The confession became the basic statement of Lutheran doctrine. In the Peace of Augsburg, signed in 1555, the Holy Roman Empire officially recognized the Lutheran churches.

The introduction of Lutheranism into Scandinavia was largely the work of the Swedish and Danish kings. In the 1520's, King Gustavus I of Sweden took over much church property and introduced Lutheranism in Sweden and in Finland, which was then under Swedish control. In 1536, King Christian of Denmark and the National As-

sembly made Lutheranism the state religion. They also established it in Norway, which was then a Danish province.

Zwingli and the Anabaptists. In Switzerland, Huldreich Zwingli, a priest in Zurich, led the movement for religious reform. Zwingli was an eloquent preacher and a great Swiss patriot. Long after his death in 1531 in a war against Catholic forces, his ideas of reform continued to inspire the Swiss Protestant churches. In 1529, Zwingli and Luther met in Marburg, Germany, to discuss their disagreement over the interpretation of Christ's presence in the Lord's Supper. Luther regarded this sacrament as a means by which God gave people His grace. He believed in the real presence of Christ in the bread and wine. Zwingli considered the sacrament a thanksgiving to God for grace already given in other ways, especially through the Gospel. He believed the bread and wine were mere symbols of Christ's body and blood. The quarrel between Luther and Zwingli led to the first major split in Protestantism.

In Zurich during the 1520's, a group known as the Swiss Brethren, led by Conrad Grebel, decided that the Scriptures did not teach infant baptism. The Swiss Brethren favoured adult baptism and were called *Anabaptists* (rebaptizers). The Anabaptists were not satisfied with Protestant efforts to reform Christianity, so they withdrew from religious and secular life and formed their own groups. The Anabaptists were persecuted by both Catholic and Protestant authorities. See **Anabaptists.**

John Calvin helped establish Protestantism in Geneva, Switzerland. From there, he directed efforts to convert the people of France and other countries of western Europe. Calvin, a refugee from France, had studied law and the classics before becoming a Protestant. He was a frail man but had an iron will and a great gift for organization. He was probably never ordained a priest. Calvin's *Ecclesiastical Ordinances* (1541) established the structure of a *presbyterian* form of church government in which a council of elders rules each church. His influential *Institutes of the Christian Religion,* first published in 1536, offers a clear, systematic presentation of Protestant teachings.

Calvin's followers in France were called *Huguenots.* They came from all classes of society, including some influential noble families such as the Bourbons. Supported by Spain, France's Catholic kings attempted to suppress the Huguenots in a series of religious wars from 1562 to 1598. Beginning on Saint Bartholomew's Day, Aug. 24, 1572, the pro-Catholic party murdered thousands of Huguenots in Paris and in the French provinces. But Protestantism survived as a minority religion, even in France. See **Saint Bartholomew's Day, Massacre of.**

In England, as in Scandinavia, the Reformation was established by an act of state. The immediate cause for England's break with the Catholic Church was the refusal of Pope Clement VII to *annul* (cancel) King Henry VIII's marriage to his first wife, Catherine of Aragon. Catherine had not borne Henry a son, and the king wanted to marry Anne Boleyn in the hope that the marriage would produce a male heir to the throne.

In 1534, Parliament passed the Act of Supremacy, which made the monarch the head of the church in England. Henry VIII remained basically a Catholic. However, Protestantism made great advances under his son, Edward VI. Queen Mary I, known as "Bloody Mary," succeeded Edward in 1553. She restored Catholicism as the state religion of England, and she suppressed the Protestants.

Queen Elizabeth I, who reigned from 1558 to 1603, established a moderate form of Protestantism that became known as *Anglicanism.* The Thirty-Nine Articles, issued in 1563 and approved by Parliament in 1571, presented the teachings of Anglicanism.

English people who followed John Calvin were called *Puritans.* They opposed Anglicanism because it was *episcopal* (governed by bishops). The Puritans preferred the presbyterian form of church government. Catholicism was officially banned. See **England** (The English Reformation).

In Scotland, John Knox introduced Calvin's teachings and presbyterian system. In 1560, the Scots made Protestantism their state religion. England forced Ireland to adopt Protestantism as the state religion, but the Irish people remained loyal Catholics. Protestants colonized northern Ireland, also known as Ulster, and the conflict there between Catholics and Protestants is still a serious problem today.

Results of the Reformation

Religious influences. As a result of the Reformation, Europe was divided between the Catholic countries of the south and the Protestant countries of the north. Many Protestant denominations developed, and they were organized in a variety of ways. In many parts of Europe, this diversity of religious life created a mood of religious toleration and a respect for the importance of the individual conscience. The Reformation also stimulated many reforms within the Catholic Church. The church gained new purity and strength during the late 1500's and the 1600's in a movement called the *Counter Reformation* (see **Counter Reformation**).

Political and social influences. The establishment of state churches, as occurred in England, contributed to the growth of nationalism. Lutheran regions tended to be conservative and supported strong central governments. Calvinist areas, where Protestants were often in the minority, tended to support democracy and argued for a citizen's right to oppose tyranny by monarchs.

Luther and other Protestants regarded life in the world as the "sphere of faith's works." They idealized family life and participation in community activities. The Protestant stress on the holiness of a person's role in daily life encouraged industriousness, thrifty living, and careful management of material things. This attitude became known as the *Protestant Ethic.* It contributed to the growth of industry and commerce during the 1700's and 1800's. See **Protestant Ethic.**

Protestant leaders also emphasized education. They promoted literacy, an educational curriculum based on ancient Greek and Roman literature, and a high respect for teachers and learning. Protestants and Catholics both contributed to great scientific achievements of the 1500's and early 1600's, including the discoveries of Galileo and Sir Isaac Newton. But after about 1640, advances in science were promoted more energetically in Protestant lands.

Related articles in *World Book* include:

Biographies

Calvin, John	Luther, Martin
Cranmer, Thomas	Mary (I)
Eck, Johann	Melanchthon, Philipp
Erasmus, Desiderius	Ridley, Nicholas
Henry (VIII)	Tetzel, Johann
Hus, John	Tyndale, William
Knox, John	Wycliffe, John
Latimer, Hugh	Zwingli, Huldreich

Reform groups

Albigenses	Lollards
Anabaptists	Lutherans
Anglicans	Presbyterians
Covenanters	Puritans
Huguenots	Waldenses

Other related articles

England (The English Reformation)	Protestantism
France (Religious wars)	Schmalkaldic League
Germany (The Reformation; The Thirty Years' War)	Scotland (The Scottish Reformation)
Nantes, Edict of	Thirty-Nine Articles
Peasants' War	Thirty Years' War
	Worms, Edict of

Reformatory is a correctional institution for lawbreakers over the age of 18 who do not need maximum security. Reformatories are often used to separate young adult offenders from older prisoners. They provide counselling, education, vocational training, and other improvement programmes.

Institutions for most lawbreakers under the age of 18 are called *training schools, borstal* or *youth detention centres.* Most inmates of training schools are held from 6 to 9 months. Institutions at which youthful offenders stay for a shorter time are called *juvenile detention centres.*

By 1900, reformatories had been established throughout the Western world. These institutions originally attempted to reform and educate the youths rather than to punish them. However, early reformatories operated much like prisons and lacked effective programmes.

Refraction is the change in the direction in which waves travel when they pass from one kind of matter into another. Waves are *refracted* (bent) when they pass at an angle from one medium into another in which the velocity of light is different. A pencil standing in water looks broken at the water line because light travels slower in water than in air.

The amount that a ray of a certain wavelength bends in passing from one medium into another is indicated by the *index of refraction* (n) between the two mediums for that wavelength. Finding n is a problem in trigonometry. It is a function of the sines of the angles of incidence and refraction:

$$n = \frac{\sin i}{\sin r}$$

This formula is also called Snell's Law after the Dutch mathematician Willebrord Snell van Royen (1591-1626), who formulated the law.

A pencil in a glass of water appears to be broken at the water's surface as a result of light refraction.

Common indexes of refraction depend on the relationship of a ray's angle in air to its angle in such mediums as glass, quartz, or plastic. The different colours in light are not refracted to the same extent because they have different wavelengths. Because of this characteristic of light, refracted light beams often break up into the colours of the spectrum. A prism works on this principle.

See also **Lens; Light** (How light behaves); **Mirage; Prism; Rainbow; Sound** (Refraction).

Refractory is any nonmetallic material or object that can withstand high temperatures without becoming soft.

Refractories are used to line furnaces for melting metals and glass, in crucibles for inducing chemical reactions and for melting materials, as insulation in the walls of furnaces and kilns, and in other places where resistance to temperature and corrosion is required. A common refractory called *firebrick* contains aluminium silicates and minor amounts of titanium and iron oxides. Other refractory substances include alumina, magnesia, silica, zirconia, silicon carbide, and graphite.

Refrigeration is the process of producing low temperatures. It takes place when heat is removed from a substance. Cooling can be achieved with ice or snow, or by machines. For thousands of years, people have used some kind of refrigeration to cool beverages and preserve food. Since the mid-1800's, refrigeration has been widely used to keep food from spoiling.

Today, people store foods in home refrigerators and freezers. Supermarkets, grocery stores and food companies use refrigerated display cases. They also keep their produce in freezing rooms and cold-storage warehouses. Fresh foods are carried long distances in refrigerated trucks, refrigerated railway cars, and refrigerated compartments of ships. People on camping trips can keep food fresh for days with portable refrigerators installed in their vehicles.

Refrigeration has many uses beside preserving food. Air conditioning depends on refrigeration to cool homes, offices, theatres, stores, and cars. Refrigeration makes it possible to store serums, vaccines, blood plasma, and other lifesaving medical supplies. Drug companies use refrigeration to make penicillin and other drugs. Cleaners and fur companies store furs in refrigerated vaults to protect them from moths and to keep the furs in good condition. Florists refrigerate cut flowers to preserve their fresh appearance. Drinking fountains supply cold water, and ice machines provide blocks, cubes, flakes, and chips of ice. Ice plants and skating rinks use refrigerating machines to manufacture ice. Industry uses refrigeration in the processing of rubber, lubricants, and steel, and in producing frozen fruit juices, sweets, photographic films, ice cream, chemicals, and many other products.

Principles of refrigeration

Refrigeration removes heat from solids, liquids, and gases. It is based on the second law of thermodynamics (see **Thermodynamics**). This law states that heat flows only from warmer bodies to colder bodies, or from a substance at a certain temperature to a substance at a

lower temperature. Heat cannot go from a colder substance to a warmer substance of its own accord. The flow of heat from warmer bodies to colder bodies is called *heat transfer.* During refrigeration, heat transfer occurs when we place the substance we wish to cool near a *refrigerant* (cooling agent).

Heat transfer. Simple heat transfer takes place when a colder substance comes in contact with a warmer substance. The temperature rises in the colder substance and decreases in the warmer substance as heat is transferred. This simple type of refrigeration occurs when we cool a warm bottle of water in a running stream. The stream acts as a refrigerant. It absorbs heat and rises in temperature as it flows over the bottle.

All substances have the ability to absorb heat. But refrigerants absorb heat quickly and in large quantities. The most common types of refrigerants include air, water, brine, ice, ammonia, carbon dioxide, sulphur dioxide, and such specially prepared substances as Freon and Carrene.

Effects of heat transfer. Heat transfer produces several effects. It both cools the warmer body and heats the body that absorbs the heat. Heat transfer may also change the physical state of a substance. For example, removing sufficient heat causes a gas to change to a liquid. This process is called *condensation.* The reverse of condensation is *vaporization* (the process of a liquid changing to a gas). Gases lose heat when they condense. Liquids absorb heat when they vaporize. The temperature at which a substance condenses or vaporizes at a given pressure is its *boiling point.* Removing enough heat from a liquid causes it to *freeze* (become solid). The temperature at which a substance freezes is called its freezing point. The reverse of freezing is *melting,* the process of changing a solid to a liquid. Liquids lose heat when they freeze. Solids gain heat when they melt.

All refrigeration systems depend on gains or losses of heat that occur during condensation, vaporization, freezing, or melting. The heat gained or lost during these physical processes is called *latent heat* (see **Heat** [Changes in state]).

Ice refrigeration

People cool food and other items with ice if they lack convenient power to produce other methods of refrigeration. Natural ice, cut from lakes and ponds in winter, has long provided refrigeration during warm seasons. Some campers and farmers cool food in iceboxes similar to those used before the development of mechanical refrigeration. Railway refrigerator cars and some refrigerated motor trucks carry ice to keep foods cool during shipment.

Ice is one of the oldest methods of refrigeration. The Chinese cut and stored ice as long ago as 1000 B.C. Ice refrigerates because it absorbs heat when it melts. For example, this absorption happens when we cool a warm drink by putting ice cubes in the glass. Ice makes a useful refrigerant because it has a constant melting temperature of 0° C. It absorbs large quantities of heat as it melts. However, the unmelted ice always maintains the same temperature. Ice is used to cool foods in iceboxes or to freeze liquids by *endothermic reactions.* These chemical reactions enable ice to produce temperatures below freezing.

Iceboxes work because warm air rises. A cake of ice in the upper part of an icebox absorbs heat from the warm air. This cools the warm air and increases its density. The heavier air flows downward to the food compartments. The air becomes warmer and lighter as it absorbs heat from the food. The warmer, lighter air rises and again loses heat to the ice.

Endothermic reactions. By itself, ice could never absorb enough heat to reduce the temperature of a substance below its own melting point of 0° C. But *endothermic reactions* (reactions that occur with the absorption of heat) enable ice to produce freezing temperatures. Certain chemical compounds, particularly salts, produce a freezing action when mixed with ice or snow, or even other compounds (see **Salt, Chemical**). Such combinations are called *endothermic mixtures.* Some mixtures of ice and chemicals produce temperatures of −40° C or lower. Endothermic mixtures include such combinations as calcium chloride and snow; ice, sodium chloride, and ammonium nitrate; and sodium sulphate, ammonium chloride, potassium nitrate, and diluted nitric acid. All these substances absorb heat during their chemical reactions.

The hand-operated ice-cream freezer is an example of the use of endothermic mixtures. Ice cream begins to freeze at about −2° C. To freeze ice cream, the ingredients are mixed in a container surrounded by crushed ice and salt. The endothermic reaction of the ice and salt absorbs latent heat from the ingredients, causing them to freeze.

Using chemicals to reduce temperature is not new. About 1550, the Italians found that a mixture of potassium nitrate (saltpetre) and water could be used to cool bottled liquors.

Dry ice is solid carbon dioxide. As a refrigerant, it has two important advantages over ice made from water. Like water ice, dry ice undergoes change at a constant temperature. But, instead of changing to a liquid, dry ice *sublimes* (vaporizes) directly to a gas (see **Sublimation**). For this reason boxes containing food packed in dry ice do not leak fluid as they would if packed with water ice. This characteristic gives dry ice its name.

Refrigeration keeps food from spoiling in a supermarket. Refrigeration prevents spoilage by keeping foods at temperatures near or below freezing. These low temperatures slow down or stop the growth of microorganisms that ruin food.

Ice was the only form of home refrigeration until mechanical refrigerators became widespread during the 1920's. Blocks of ice were delivered to home iceboxes several times a week.

Dry ice sublimes at −78.5° C, which is much lower than the melting temperature of water ice. Companies involved in food processing find dry ice especially valuable for maintaining a freezing temperature in foods and ice cream, because it produces much lower temperatures than water ice. Dry ice must be handled carefully, because it can cause frostbite and severe burnlike injuries. See **Dry ice**.

Mechanical refrigeration

Mechanical refrigeration works on the principle that liquids absorb heat when they vaporize. You can demonstrate this by wetting your hands and waving them rapidly. The water evaporates quickly and causes a cooling sensation by lowering the skin temperature. A fan cools you because it evaporates the natural moisture on your skin.

Mechanical refrigeration includes three principal systems. They are (1) compression, (2) absorption, and (3) steam-jet.

Compression and absorption systems refrigerate by changing a refrigerant from a liquid to a gas and back to a liquid again. These repeated operations make up the *refrigeration cycle*. In a compression system, a compressor brings about the refrigeration cycle. This system is widely used in industry and in most home electric refrigerators. In the absorption system, the refrigeration cycle is caused by the direct application of heat from gas, steam, or some other source. All home and camper gas refrigerators, and some industrial units, use the absorption system. Jacob Perkins, an American inventor, developed the first compression machine in 1834. During the 1850's, Ferdinand Carré, a French engineer, developed the first absorption system using ammonia. Carl von Linde of Germany introduced the first successful compression system using ammonia between 1873 and 1875.

Electric and gas home refrigerators are hermetically sealed, or airtight and leakproof, refrigeration units that maintain cooling temperatures between 0° C and 4° C. Most have freezing compartments with temperatures between −18° C and −12° C.

Steam-jet refrigeration uses water as a refrigerant. High-velocity steam brings about the refrigeration cycle. Steam-jet refrigeration is less common than the compression system because its temperature is limited to about 2° C and above.

The electric refrigerator is a compression-type refrigeration unit powered by an electric motor. A home electric refrigerator consists of five basic parts: (1) the receiver, (2) the refrigerant-control device, (3) the evaporator, (4) the compressor, and (5) the condenser.

At the beginning of the refrigeration cycle, the refrigerant, Freon 12 in most cases, leaves the *receiver* (storage tank) under high pressure. It travels through pipes to the *refrigerant-control device*. This mechanism reduces the pressure of the refrigerant as it enters the *evaporator*. The evaporator is the coldest spot in the refrigerator and serves as the freezing unit. The evaporator consists of pipes or coils on the walls or sides of the cabinet, or surrounding the ice-tray compartment. At a low pressure, the liquid refrigerant evaporates inside these coils and absorbs heat. This causes refrigeration to take place. The *compressor* pumps the refrigerant from the freezing unit as a vapour, and raises its pressure. It then discharges high-pressure gas into the air-cooled *condenser*. There the gas loses the heat it gained in the evaporator and condenses into a liquid at the high pressure. The liquid refrigerant flows back to the storage tank.

The gas refrigerator works on the absorption principle. It uses heat energy as a source of power, and has no moving parts. A home gas refrigerator consists of five basic parts: (1) the generator, (2) the separator, (3) the condenser, (4) the evaporator, and (5) the absorber. Liquid ammonia serves as the refrigerant in most gas refrigerators.

During the refrigeration cycle, heat from a gas flame is applied to the *generator*. This tank contains a strong solution of ammonia gas dissolved in water. The heat causes the solution to boil. Ammonia vapour and some of the solution rise to the *separator*, which removes the liquid. The hot gas continues its rise to the *condenser*, where it is cooled and liquefied. Since the water has been separated from the ammonia, the liquid is now almost pure ammonia. The liquid ammonia flows through a tube into the *evaporator*, or freezing unit, where it vaporizes with hydrogen gas. The hydrogen equalizes the pressure between the condenser and the evaporator. The vapour absorbs heat and produces refrigeration. The heavy mixture passes downward into the air-cooled *absorber*, where the ammonia is absorbed by water. The light hydrogen gas separates from the solution, rises through a pipe above the absorber, and returns to the evaporator. The cool ammonia-water solution flows back to the generator.

Steam-jet refrigeration uses only water as a refrigerant. Steam-jet refrigeration systems work on the principle that water vaporizes easily when it is under low pressure. As the water evaporates, its temperature goes down. The lower the pressure on the water, the faster

the evaporation and, as a result, the lower the temperature produced.

The water flows through a chamber with an opening, across which a high-speed jet of steam passes. The steam creates suction within the space above the water, and lowers the pressure in the chamber. Some of the water evaporates and absorbs heat from the liquid in the chamber. The cool water is pumped out through pipes that carry it to wherever it is to be used. The water vapour rising from the chamber combines with the steam and is removed from the system.

Steam-jet systems produce practically no noise or vibration, occupy little space, and have no moving parts except a pump. Steam-jet systems require a constant supply of steam, but this may come from the exhaust of other machinery. Steam-jet refrigeration has wide use in industrial and shipboard cooling. In addition, many brewers and distillers make use of this type of mechanical refrigeration.

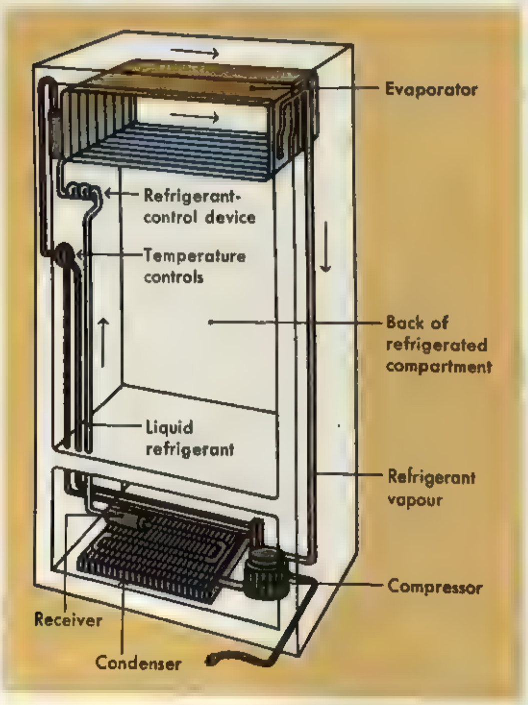
Low-temperature refrigeration works very much like other compression systems, except that it uses different refrigerants. Low-temperature refrigerators are called *cryogenic refrigerators* or *cryocoolers*. They can produce temperatures as low as −273° C, very near absolute zero. Cryogenic refrigerators have important uses in science and industry. For example, doctors use them to freeze living parts of the body for future use. Manufacturers use them to cool miniature electronic systems. See **Cryogenics**.

A cryogenic refrigerator uses helium, nitrogen, or other gas as a refrigerant. It works by changing the refrigerant from a gas to a liquid and back to a gas again. Helium is used as the refrigerant in the lowest-temperature refrigeration because it is the only substance that can remain liquid below −259° C. A simple cryogenic refrigerator consists of four basic parts: (1) the compressor, (2) the heat exchanger, (3) the expansion valve, and (4) the evaporator.

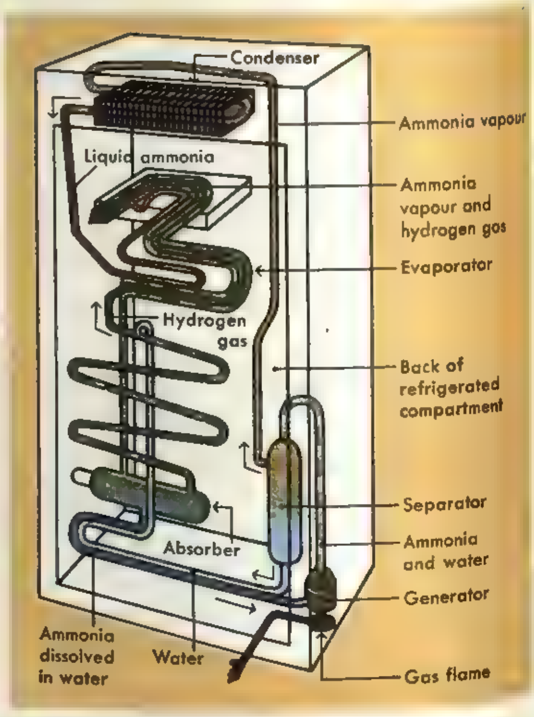
During the refrigeration cycle, the gas leaves the compressor under high pressure and moves through a tube to the heat exchanger. There, it transfers some of its heat to a stream of cooler gas. The refrigerant then passes through an expansion valve. This process greatly reduces the pressure of the gas. As the gas expands, its temperature drops until part of the gas condenses. The liquid refrigerant then flows through a tube into the evaporator, which serves as the refrigerating unit. As it goes through the evaporator, the refrigerant absorbs heat and becomes a gas again. The gas returns through the heat exchanger, and the cycle repeats.

Defrosting

Defrosting is probably the most important part of caring for a refrigerator. The coating of frost that collects on the freezing unit acts as insulation and interferes with the refrigerator's cooling ability. Because of this, the refrigerator should be defrosted regularly. The defrosting process may be automatic, semiautomatic, or manual.



An electric refrigerator circulates a refrigerant through pipes with an electrically-driven compressor. The liquid refrigerant picks up heat in the evaporator inside the refrigerator. The compressor then pumps the refrigerant vapour into the condenser, where it gives up its heat outside the refrigerated compartment.



A gas refrigerator circulates an ammonia refrigerant, using heat from a gas flame, and an absorber, a generator, and a separator. The ammonia vapour loses heat in the condenser and becomes a liquid. It then picks up heat from the refrigerated compartment and becomes a vapour again in the evaporator.

Automatic defrosting takes place at a certain time each day, or after the door has been opened a certain number of times. The controls open a valve that allows hot gas from the compressor to flow through the coils and melt the frost. During this time, refrigeration is stopped. In some refrigerators, the controls activate an electric heater close to the coils. In many automatic-defrosting refrigerators, the drip water from the coils drains from the cabinet through an opening near the compressor. The heat from the compressor evaporates the water. Automatic defrosting takes little time, so there is no danger that food will spoil while refrigeration is stopped.

Semiautomatic and manual defrosting. Refrigerators can be defrosted by turning them off. In a manual type, a hand-operated switch turns off the freezing unit. When defrosting is completed, the hand-operated switch starts the freezing unit again. A semiautomatic refrigerator must be turned off manually, but it starts again automatically when defrosting is completed.

Related articles in *World Book* include:

Air conditioning	Food preservation
Ammonia	Freezing point
Boiling point	Heat
Cold storage	Ice
Cryogenics	Melting point
Dry ice	Railway (picture: Refrigerator cars)
Fluorocarbon	
Food, Frozen	

Refugee is a person who is forced to flee his or her country of origin and seek safety elsewhere. Most refugees flee to escape persecution because of religion, nationality, membership of a particular social group, or political belief. The term *refugee* comes from the French word *refugie,* which was used to describe Protestant Huguenots who fled Roman Catholic France in 1685.

The term *displaced person,* or DP, was originally applied to the millions of European refugees who were forcibly moved from their homes during and immediately after World War II (1939-1945). Since then, the terms displaced person and refugee have sometimes been used interchangeably. Both terms refer to people who are uprooted and homeless. But refugees also lack national protection and status.

Just before and during World War I (1914-1918), there were many Jewish refugees fleeing from *pogroms* (persecutions) in Russia. Over $1\frac{1}{2}$ million refugees fled from Russia during the Russian Revolution from 1917 to 1920. There were also many Greek and Armenian refugees from Asia Minor (now Turkey) both during and after World War I. Europe had so many refugees after World War I that in 1921 the League of Nations appointed the famous Norwegian explorer and scientist Fridtjof Nansen as a special commissioner to help the refugees. After Nansen died in 1930, the League established the International Office for Refugees.

The number of refugees increased again before and during World War II. Between 1933 and 1941, hundreds of thousands of Jews and other opponents and victims of the Nazis fled Germany and German-controlled areas. During World War II, the Allied nations set up the United Nations Relief and Rehabilitation Administration (UNRRA) to help people uprooted and displaced by the war. At the war's end in 1945, there were over 12 million uprooted people in Europe. In 1946, the United Nations established the International Refugee Organization (IRO) to take over the work of UNRRA. The IRO aided many displaced persons in Europe. It also helped millions of people who fled as a result of the *partition* (division) of India in 1947, the partition of Palestine in 1947, and the Arab-Israeli War in 1948.

Wars and revolutions have continued to create large numbers of refugees. More than $1\frac{1}{2}$ million people fled from Cambodia, Laos, and Vietnam between 1975, when Communists took over the three countries, and the early 1990's. Millions had also left China (including Tibet) and Palestine as well as countries in Africa, Asia, Central America, and Eastern Europe by the early 1990's.

In 1990 and 1991, over 2 million refugees and about $1\frac{1}{2}$ million guest workers fled Iraq and Kuwait as a result of the Persian Gulf War. Also, in the 1990's, more than $4\frac{1}{2}$ million people in Yugoslavia and its former republics became refugees or displaced persons as a result of civil war in the region. Fighting in the Russian republic of Chechnya in 1994 caused about half a million Chechen refugees to flee the area. Drought and civil wars in Ethiopia and Somalia, as well as civil war in Sudan, all contributed to Africa's refugee problem in the early 1990's. Over two million people fled the civil war in Rwanda in 1994, escaping to United Nations camps in Zaire, Tanzania, and Burundi.

International programmes helped some of these refugees, as well as others from Bangladesh, China, Eastern Europe, Haiti, and Palestine. Millions of people have been moved to new homes by the Intergovernmental Committee for European Migration (now Intergovernmental Committee for Migration) and the UN Office of the High Commissioner for Refugees.

See also **Asia** (picture: Arab refugees); **Asylum; Nansen, Fridtjof; United Nations** (Aid to refugees).

Refuse. See **Waste disposal.**

Regelation is the process in which ice melts under pressure and refreezes as soon as the pressure is taken away. If two blocks of ice near 0 °C are pressed together, they will be found frozen together when the pressure is taken off. At 0 °C, water is denser than ice. Therefore, ice when compressed changes into water. When the pressure is removed, the water expands and refreezes.

A skate passing over ice places pressure on the ice and melts a thin film of water. The skater glides on this water. A heavy object placed on ice will gradually sink into the ice and bury itself as the ice melts under the object and refreezes above it.

A glacier moving along slowly melts and refreezes, slipping a little under pressure each day. In the Ice Age, regelated ice in central Canada pushed continental glaciers 730 metres up the sides of the Rocky Mountains.

Regeneration, in plants and animals, is the capacity to replace lost or damaged parts by growing new ones. Regeneration is common in plants. If a tree or shrub is cut off near the ground, new shoots may spring up from the stump. Among animals, the sponges, cnidarians, and the simpler worms show remarkable power of regeneration. They can be cut in pieces, and each piece can grow into an entirely new animal. Starfish can grow new arms. Crayfish, crabs, and other related animals can grow new claws, eyes, and legs.

Animals with a backbone—called *vertebrates*—have only limited powers of regeneration. But many lizards

can escape from their enemies by breaking off the end of their tail. Later they grow a new one. Salamanders are amphibians that can regenerate lost limbs. People and other mammals can regenerate only hair, nails, skin, and a few other tissues. In some cases, a different sort of tissue grows over the damaged area and forms a scar.

See also **Crustacean** (Growth and development); **Flatworm; Lizard; Planarian; Sponge** (Regeneration).

Regent is a person who rules a country when the rightful ruler cannot, either because he or she is too young, out of the country, or ill. In some countries, a member of the royal family acts as regent. In others, a council may exercise the duties of the ruler.

The British had no special arrangements providing for a regency until the Regency Act of 1937 was passed. This law provides for the appointment of a regent if the monarch is unable to rule. A council of state can act as regent for short periods of time. This council is composed of the husband or wife of the ruler and the next four persons in succession to the crown.

In the United States, members of the governing body of libraries, museums, school systems, and universities and colleges are called *regents.*

Regent diamond. See **Diamond** (Famous diamonds).

Reggae is a type of popular music that developed in Jamaica in the 1960's. At first it was primarily performed by and for poor Jamaicans. It later became popular throughout Jamaica and also in England and the United States. Reggae has influenced soul, rhythm and blues, and rock music.

The words in most reggae songs deal with the social concerns and religious beliefs of poor Jamaicans. The songs are in $\frac{4}{4}$ time and feature strong accents off the beat. Short rhythmic patterns are repeated many times by electric guitars and drums. They are also sometimes repeated with organ or piano. The rhythms in reggae are sometimes complex, but the harmonies are simple. As with rock music, the volume of reggae is loud.

Reggae has its roots in traditional African music, Jamaican folk music, and North American popular music. It developed from two other types of Jamaican popular music—*ska* and *rock steady.* Reggae began to gain popularity outside Jamaica in the late 1960's through the recordings of a number of reggae musicians. The most important was Bob Marley, who grew up in the slums of Kingston, Jamaica. Marley led a group called the Wailers, founded in 1964. He was the most internationally famous reggae star until his death in 1981 at the age of 36 (see **Marley, Bob**). Songs that became hits in the United States include Eric Clapton's "I Shot the Sheriff" and Johnny Nash's "Stir It Up" (both written by Marley) and Desmond Dekker's "The Israelites."

Regiment is a military organization responsible for housing and organizing a group of soldiers and their equipment. Many regiments are made up of a number of small groups such as *battalions* of infantry, *squadrons* (armoured troops) or *batteries* (artillery). Infantry regiments may have as few as two battalions in peacetime or as many as 15 in war.

Modern armies do not fight as regiments, but combine battalions, squadrons, and batteries from several different regiments into *brigades* of between 4,000 and 8,000 men. Battalions in the same regiment do not necessarily serve together, and it is quite common for them

Many British regiments have animals as mascots. The Royal Welsh Fusiliers have a goat as a mascot. The mascot appears with the regiment in formal parades and other public events.

to be attached to different brigades.

In England, regiments were first formed in the 1500's when commanders began to "regiment" (group their men under a centralized command). Initially, commanders were responsible for the upkeep of their regiments and for the appointment of officers whose *commissions* (letters of appointment) they bought and sold. Later regiments received more formal titles and the award of commissions became centralized.

Many of the titles of modern regiments indicate their roles when originally formed. For example, dragoon guards were heavy cavalry, hussars and lancers were light cavalry, and fusiliers were infantrymen armed with guns called *fusils* (flintlock muskets). Other requirements commemorate earlier national heroes. An example is the United States 75th (Ranger) Regiment, which perpetuates the history of Roger's Rangers (see **Roger's Rangers**). Some regiments formed in more recent times have titles which clearly indicate their specialist role, such as the British Parachute Regiment, the French 2eme REP (Regiment Étranger de Parachutistes) and the Australian SASR (Special Air Services Regiment).

Region is a geographical area identified by some characteristic such as scenery or the nature of its economy. It can also be an area that is clearly defined for purposes of planning, industrial development, or administration. In Scotland, regions are the main areas of local government, for example Highland Region and Strathclyde Region. In France, the administrative regions are called *départements* (departments), and are numbered.

Register office, in the United Kingdom and Commonwealth countries, is where parish records of births, marriages, and deaths are kept. The Registration of Births and Deaths Act of 1953 states that a birth must be registered within six weeks and a death within five days. People may also get married by signing the register at a register office. Certificates are issued in connection with the registration of a birth, death, or marriage. In 1538,

Thomas Cromwell, chief minister of Henry VIII, decreed that parish records be made weekly. The title of the keeper of these records was originally a *register.* But, in the 1800's, the keeper came to be called a *registrar.*

Registration of voters. See **Voting.**

Regression is a characteristic sign of certain mental illnesses. It comes from a Latin word meaning *to go backward.* Doctors use the word to mean a return to a way of thinking or behaving that would normally be characteristic of an earlier period of life. For example, if a 4-year-old child, after the birth of a baby brother or sister, began to act like a baby, doctors would call the child's behaviour regression.

Regulus, Marcus Atilius (? -249? B.C.), was a Roman general who became a national hero. His life story was repeated as an example of true patriotism. As *consul* (chief government official) in 256 B.C., he commanded the victorious Roman invasion of Africa against Carthage in the First Punic War (see **Punic Wars**). But he demanded unconditional surrender. Instead, the Carthaginians raised more troops and hired Xanthippus, a Spartan general, who defeated the Romans and captured Regulus.

Carthage sent Regulus to Rome about 249 B.C. with peace terms. He promised to return if the Romans refused to make peace. Regulus urged the Roman Senate not to accept the terms, though he knew this meant his death when he returned to Carthage. Romans later said he was killed by torture by the Carthaginians, but this story may have been made up by his family. Regulus was an aristocrat, but he was not rich. Before the war, he lived a simple life on his farm.

Rehabilitation. See **Hospital** (Professional services departments); **Speech therapy; Criminology** (What criminologists study).

Rehabilitation medicine. See **Handicapped** (Overcoming handicaps).

Reibey is the name of a family that took an active part in business and politics in Australia.

Mary Reibey (1777-1855) was an astute businesswoman who had interests in land, shipping, and retailing in Sydney. She also took an active interest in community activities. She was born in England and was named Mary Haydock. At the age of 13, she was transported to Australia for seven years on a charge of horse stealing. She arrived in Sydney in October 1792. In 1794, she married Thomas Reibey, one of the colony's first free and independent merchants.

Thomas Reibey (1821-1912), the grandson of Mary and Thomas Reibey, became premier of Tasmania. Before he entered parliament, he was Anglican archdeacon of Launceston.

Reich is a German word meaning *empire* or *state.* Adolf Hitler, the German dictator, called his government the *Third Reich.* The first was the Holy Roman Empire. The second was the German Empire that lasted from 1871 to 1918 (see **Germany** [History]).

Reichstadt, Duke of. See **Napoleon II.**

Reichstag. See **Germany** (History); **Hitler, Adolf** (The New Order).

Reichswehr is the German term for *army of the state.* The German republic set up a Reichswehr in 1919 from volunteer units called *Free Corps.* It had about 300,000 troops. The Treaty of Versailles forced Germany to cut it to 100,000 troops. Army leaders retained only outstanding soldiers, and developed an efficient general staff and *cadres* to train new troops. The Reichswehr became the nucleus of German armed forces in World War II.

Reid, Sir George (1845-1918), was premier of New South Wales, Australia, from 1894 to 1899 and prime minister of Australia in 1904 and 1905. Throughout his career, he strongly believed that free trading between the colonies would do more to develop industry than protective tariffs. In the federal Parliament, he was leader of the free trade group. He managed to force the federal government to compromise between free trading and protectionism. As prime minister, he led a coalition government of his party and the Liberal Party led by Alfred Deakin.

George Houston Reid was born in Scotland. He arrived in Australia in 1852. He became a barrister in 1879 and entered the Legislative Assembly in 1880. He was knighted in 1909.

Reigate and Banstead (pop. 114,900) is a local government district in Surrey, England. The residential town of Reigate is situated at the foot of the North Downs. Nearby Redhill has light engineering among its industries. Banstead and other villages are surrounded by woodlands and open commons. Sheep graze on the Downs. In the lowland areas, dairy and arable farming are important. See also **Surrey.**

Reign of Terror. See **French Revolution** (Terror and equality).

Reims (pop. 185,164; met. area pop. 206,362) is a fortified city of northern France. It is on the Vesle River about 158 kilometres northeast of Paris. For location, see **France** (political map). The beauty of Reims centres on a cathedral, which was begun in the 1200's and completed in 1430. This cathedral towers high above the surrounding homes.

During World War I, Reims was bombed daily for nearly four years. After the war ended in 1918, the peo-

The Cathedral of Notre Dame in Reims, France, is a beautiful example of Gothic architecture. It was completed in 1430.

ple rebuilt many homes and buildings. World War II brought more suffering to the city. The Germans occupied Reims from 1940 to 1944. Reims later became an important supply base for Allied troops. The Germans signed their surrender at Reims on May 7, 1945.

Reims lies in one of the important wine regions of France, and leads in French champagne production. It is also France's most important wool market. Other products made in Reims include machinery, chemicals, soap, paper, and wine bottles and casks.

Lovers of art and architecture have long admired the Cathedral of Notre Dame at Reims, one of the most beautiful examples of Gothic architecture. Nearly all the French kings were crowned in the cathedral. Heavy bombing during World War I badly damaged the cathedral, but it was repaired by 1937.

Reincarnation is the belief that the soul survives after death and is reborn in the body of another person or some other living thing. This concept is also called *transmigration of the soul.* The word *reincarnation* means *coming back into the flesh.*

The ancient Greeks and some primitive peoples believed in reincarnation. The concept is an important part of Buddhism, Hinduism, Jainism, Sikhism, and other religions that originated in India. It also is a doctrine of some modern *spiritualist* movements (see **Spiritualism**).

In the religions of India, reincarnation is related to the law of *karma.* According to this law, a person's actions determine the type of body that the soul will enter during reincarnation. If a person leads a good life, his or her soul will be reborn in a higher state, such as the body of a priest. If a person leads a bad life, the soul will be reborn in a lower state, such as the body of a dog.

Other religions explain reincarnation in different ways. Some teach that the soul may be reborn in the body of a descendant of the person.

Related articles in *World Book* include:

Buddhism	Pythagoras
Hinduism (Reincarnation)	Religion (A doctrine of salvation)
Jainism	Sikhism
Karma	Theosophy
Plato (Immortality of the soul)	

Reindeer is a kind of large deer that lives in the northernmost regions of Europe and Asia. The reindeer, which is closely related to the caribou, is often herded and tamed by nomadic peoples.

Reindeer differ from most other forms of deer in several ways. For example, reindeer have larger antlers, larger and wider hoofs, and a heavy coat that is greyish-brown to almost white. These features help reindeer survive in the cold Arctic. The large hoofs, for example, prevent the reindeer from sinking into the snow during winter. Female reindeer are the only kind of female deer except caribou to have antlers. Reindeer often make a variety of noises. When frightened, adults snort and young reindeer bawl. When reindeer walk, their feet make a clicking sound.

In summer, reindeer may eat grasses and leaves from willows and birches. In winter, they paw through the snow to find lichens to eat. In the short Arctic summers, plants grow slowly and cannot stand much grazing. So reindeer move frequently to a new place when their food becomes scarce. They may migrate several hundred kilometres in a year. They are excellent swimmers

The reindeer lives in Arctic regions of Europe, Asia, and North America. Nomadic peoples of these far northern lands herd and tame these animals. They drink reindeer milk, eat reindeer meat, and make clothing and tents from reindeer hide.

and can cross rivers. During migration, several thousand reindeer may gather into one herd. By travelling in herds, individual reindeer are protected from their enemies. Animals that prey on reindeer include wolves, lynxes, wolverines, and grizzly bears.

A male reindeer is known as a *bull.* The female is called a *cow.* In the autumn, the bulls fight with one another to gather their own group of cows, called a *harem.* A bull then mates with the cows in its harem, and later the harem breaks up. In the spring, a cow usually will bear one offspring, called a *calf.* After a few days, the calf is strong enough to join the herd. Adult reindeer stand about 90 to 120 centimetres high and weigh up to 180 kilograms.

Reindeer are very useful to the Lapps of northern Scandinavia. The Lapps are one of the nomadic peoples well known for developing much of their way of life around the migrating herds of reindeer. They have trained reindeer to serve as pack animals and to pull sledges and sleighs. They use reindeer skin for boots, clothing, and tents. They also drink reindeer milk and kill wild reindeer for meat. In some areas, snowmobiles, trucks, helicopters, and two-way radios are used to capture and herd the reindeer. But nomads in extreme northern Siberia still herd the reindeer in the old way, following the herds, with their possessions carried on a reindeer-pulled sledge.

After the nuclear accident at Chernobyl in the Soviet Union in 1986, radioactivity was carried by seasonal winds to northern Scandinavia. The lichens that reindeer feed on were heavily contaminated and soon after the reindeer themselves became contaminated. The radioactivity level in the reindeer meat was found too high for human consumption and as a result thousands of reindeer had to be slaughtered.

Scientific classification. Reindeer belong to the deer family, Cervidae. They are subspecies of *Rangifer tarandus.*

See also **Deer; Caribou; Tundra.**

Reindeer moss is a type of lichen that grows in the arctic regions and sometimes farther south. It is an im-

portant food for the caribou and reindeer of the Arctic. Sometimes, people eat reindeer moss. In Scandinavia, it has been used to make bread. See also **Lichen.**

Scientific classification. Reindeer moss is genus *Cladonia,* species *C. rangiferina.*

Reiner, Fritz (1888-1963), was one of the great symphony orchestra and operatic conductors of his time. He became especially noted for his performances of the music of central European composers. Orchestras trained by Reiner gained fame for the precision as well as the excellence of their playing.

Reiner was born and educated in Budapest, Hungary. From 1914 to 1921, he served as musical director of the Dresden Royal Opera in Germany. He came to the United States in 1922 as director of the Cincinnati Symphony Orchestra and held that position until 1931. Reiner then taught at the Curtis Institute of Music in Philadelphia until 1941. From 1938 to 1948, he conducted the Pittsburgh Symphony. Reiner served as a major conductor at the Metropolitan Opera in New York City from 1949 to 1953. He served as musical director of the Chicago Symphony Orchestra from 1953 until his death.

Reinforced concrete. See **Cement and concrete** (Reinforced concrete).

Reinforcement, in psychology. See **Learning** (Classical conditioning; Instrumental conditioning).

Reinhardt, Max (1873-1943), was an Austrian theatrical producer and director. He became a leader of the German-speaking theatre during the early 1900's.

Reinhardt was born in Baden, near Vienna. His real name was Max Goldmann. Beginning in 1917, he helped found and plan the famous Salzburg music and theatre festival. He directed the festival's first production in 1920. He staged the Greek tragedies *Oresteia* and *Oedipus Rex* as mass spectacles. For the pantomime-pageant *The Miracle,* Reinhardt rebuilt the inside of theatres to resemble a Gothic cathedral. He moved to the United States in 1934.

Reith, Lord (1889-1971), John Charles Walsham Reith, was the first director-general of the British Broadcasting Corporation (BBC), from 1927 to 1938. He was born at Stonehaven, Grampian Region, Scotland, and educated at Gresham's School, in Holt, and at the Royal Technical College, in Glasgow. During World War I, he was in charge of various munitions contracts. In 1922, he became the first general manager of the BBC. He became chairman of British Overseas Airways Corporation in 1939. During World War II, he served in various ministerial positions.

Relapsing fever is an infectious disease that occurs chiefly in the tropics, often as an epidemic. It is caused by bacteria called *spirochaetes.* A person with relapsing fever develops chills, fever, headache, and muscular aches and pains. Vomiting also may occur. These symptoms may last for several days or a week. Then the patient seems to return to good health for about a week. Suddenly, however, the symptoms return, and if the patient is not treated, he or she may have as many as 10 relapses. Doctors advise bed rest and use antibiotics to treat the disease.

Lice and ticks transmit the bacteria to human beings. Like typhus, louse-borne relapsing fever is found in regions with poor living conditions (see **Typhus**). The two diseases often occur together.

Relativity. Einstein's theory of relativity has caught the imagination of the average person more than any other physical theory in history. Yet the theory of relativity, unlike many other results of physical science, is not easily understood by the average person. We can understand the relativity theory fully only by means of the mathematical formulas which make it up. Without mathematics, we can only state some of its basic ideas and quote, but not prove, some of its conclusions.

The relativity theory deals with the most fundamental ideas which we use to describe natural happenings. These ideas are time, space, mass, motion, and gravitation. The theory gives new meaning to the old ideas that these words represent. It is basically made up of two parts. One is the special, or restricted, relativity theory, published by Albert Einstein in 1905. The general relativity theory was put forward by Einstein in 1915.

Special theory of relativity

This theory is called the special relativity theory because it refers to a special kind of motion. This is uniform motion in a straight line, that is, with constant *velocity.* Suppose we are on a smoothly running railway train which is moving at a constant velocity. In this train you may drop a book, play catch, or allow a pendulum to swing freely. The book will appear to fall straight down when it is dropped; the ball will travel directly from the thrower to the catcher. All these activities can be carried on in much the same way and with the same results by people standing still on the ground outside the train. So long as the train runs smoothly, with constant velocity, none of our mechanical activities will be affected by its motion.

On the other hand, if the train stops or speeds up abruptly, our activities may be changed. A book may be jarred from a seat and fall without being dropped. A ball will travel differently.

One way of stating the principle of this theory is to say that the laws of mechanics are the same for an observer in a smoothly moving train as for the observer at a fixed position on the ground. Physicists would say: *if two systems move uniformly relative to each other, then all the laws of mechanics are the same in both systems.* This principle may be called the classical relativity principle. This principle is as old as the ideas of mechanics and physics.

Suppose we have a long train much like the train in the previous example. But instead of rolling along at a normal speed, it will be moving uniformly at a speed of, let us say, 32,000 kilometres per second. Instead of having two persons playing catch on the train, we will have a radio aerial on the train sending out radio waves, or an electric torch sending out light signals. Observers on the train will measure the velocity of the radio waves and light signals. On the ground we will also have an aerial or electric torch, and observers measuring the velocity of the signals. Is the velocity of the radio or light waves the same for those on the ground as it is for those on the train? If we had asked this question of physicists in the late 1800's, they would have said no. They would have said the classical relativity principle holds true for mechanical activities, but not for those of electromagnetic waves, that is, not for radio or light waves.

A physicist would have said that radio and light waves travel through *ether* at a velocity of 299,792 kilometres per second. Ether was a substance that scientists imagined to fill all space, to account for the transmission of light in outer space. The physicist would have said that the stars, sun, planets, and our imaginary moving train move through the ether sea at different speeds. Thus, the velocity of light will be different for an observer on the sun, on the earth, and on the train. Just as the earth changes velocity during the year in which it completes its journey around the sun, the speed of light for the observer should change too.

Scientists of that time held the theory that the ether through which all objects of the universe were believed to move provided a nonmoving frame of reference. All other motions could be judged from this frame of reference. Ether was looked upon as a fluid or elastic solid. It was believed to occupy the spaces between the atoms that made up matter. It offered no resistance to the earth's movement.

Among the many experiments which helped destroy the ether theory, the most famous is that of Michelson and Morley in 1887. Their measurements of the speed of light showed that the motion of the earth as it moved around the sun had no influence upon the velocity of light. Therefore, light has a uniform velocity, regardless of the frame of reference. This experimental result seemed strange, since normally we expect the measured speed of an object to depend on how fast the observer is moving.

Einstein asserted that the relativity principle was true for all phenomena, mechanical or electromagnetic. In other words, there was no special, or nonmoving, frame of reference for electromagnetic phenomena.

The basic ideas of the special relativity theory are found in a mathematical formulation of two postulates. The first is that the relativity principle is valid for all phenomena. The second postulate is that the velocity of electromagnetic waves, or light, in empty space is constant, and furthermore is independent of the velocity of its source or observer.

The following deductions have been made from these postulates by mathematical means.

According to the special relativity theory, a material body can only move with a velocity lower than that of light.

If a conductor on a fast-moving train compared his clock with the many clocks in the stations he passed, he would find that the rhythm of his clock is faster than the rhythm of the clocks on the ground. On the other hand, it will appear to the stationmasters that the rhythms of their clocks are faster than the rhythm of the conductor's clock on the train passing the station. This effect is small, and could be detected only if the velocity of the one clock that passes many others were not very small compared with the speed of light.

Two events judged as taking place at the same time by the observer in the train may not be simultaneous for the observer on the ground.

The length of every object resting in the train appears to the observer outside to be shortened in the direction in which the train is moving.

Perhaps the most important of these deductions is the fact that mass is not unchangeable. The mass of an object increases with its velocity. Theoretically, the mass of an object would become infinite if its velocity became the velocity of light. This mass increase has been observed with experiments. A small particle of matter accelerated to 86 per cent of the speed of light has twice as much mass as it does when it is at rest.

The theory also shows a relation between a body's mass and its energy ($E=mc^2$). This relation has great practical importance in the liberation of the energy in the nucleus of an atom. When energy is liberated from the nucleus of the uranium atom and atoms of other elements are formed, the total mass of these atoms is less than the total mass of the uranium atom. This means that some of the mass of the nucleus of the uranium atom has been transformed into energy. The $E=mc^2$ law shows that the energy in a single uranium nucleus is 220,000,000,000 electronvolts, providing that all its mass could be converted to energy. However, splitting the uranium nucleus, a process known as *fission*, releases only 0.1 per cent of the total energy content. This amount is still about a million times greater than the energy released in the burning of chemical fuels.

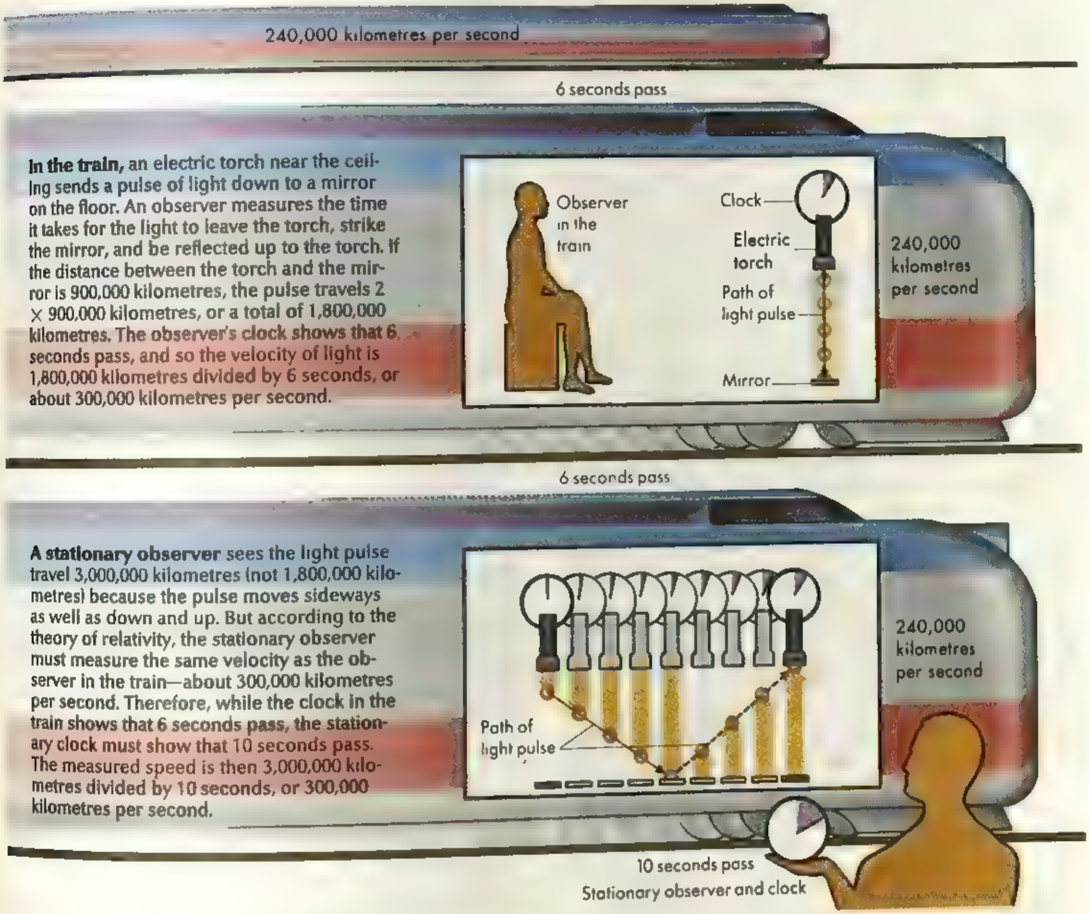
Various experiments have proved the truth of many of these conclusions about relativity. In 1938, H. E. Ives used a hydrogen atom as a moving clock. He found that a fast-moving hydrogen atom does slow down in its rhythm, just as Einstein predicted the moving clock would do. This slowing down could be shown by a change in the frequency of the line given off in its spectrum. The changes of mass as predicted by the special theory of relativity are observed in machines that are used to accelerate electrons and nuclear particles to the high speeds necessary to study nuclear properties.

The mathematician H. Minkowski gave a mathematical form to the special relativity theory in 1907. A line involves only one dimension. We can locate any point on a sheet of paper by measuring from that point to any two sides of the paper that are perpendicular to each other. Therefore, we can say that any point on a sheet of paper involves two dimensions. All points in space involve three dimensions: height, length, and breadth. But there is one other important fact involved. In physics as well as history we must deal with events. When and where did the French Revolution start, for example? When and where does the earth have the smallest velocity in its movement about the sun? Events must be characterized by four numbers, bringing in the idea of a fourth dimension. Three of these numbers answer the question *where;* one must answer the question *when.* Answering the question *when* involves the idea of time. Then we consider things in terms of four dimensions.

This question of answering when and where an event took place becomes more complicated, according to the theory of special relativity, because rods can change their lengths, and clocks change their rhythms, depending on the speed at which they operate when they are in motion. Therefore, we must answer the questions *when* and *where* an event took place in terms of a definitely moving system, or in terms of the relationships between two moving systems. For example, if we know when and where an event took place for an observer on our swiftly moving train, and if we know the velocity of the train, we can find out when and where the same event took place for an observer on the ground. The mathe-

Relativity and time

According to the theory of relativity, a clock moving relative to an observer appears to run slower than a stationary clock. This effect can be observed if the clock travels almost as fast as the speed of light, 299,792 kilometres per second. The illustrations below show a clock experiment performed in an imaginary train travelling 240,000 kilometres per second.



In the train, an electric torch near the ceiling sends a pulse of light down to a mirror on the floor. An observer measures the time it takes for the light to leave the torch, strike the mirror, and be reflected up to the torch. If the distance between the torch and the mirror is 900,000 kilometres, the pulse travels 2 × 900,000 kilometres, or a total of 1,800,000 kilometres. The observer's clock shows that 6 seconds pass, and so the velocity of light is 1,800,000 kilometres divided by 6 seconds, or about 300,000 kilometres per second.

A stationary observer sees the light pulse travel 3,000,000 kilometres (not 1,800,000 kilometres) because the pulse moves sideways as well as down and up. But according to the theory of relativity, the stationary observer must measure the same velocity as the observer in the train—about 300,000 kilometres per second. Therefore, while the clock in the train shows that 6 seconds pass, the stationary clock must show that 10 seconds pass. The measured speed is then 3,000,000 kilometres divided by 10 seconds, or 300,000 kilometres per second.

matical formulation of the theory of special relativity tells us how to find these four numbers, characterizing an event in one system from an event in another. It tells us that the question *when* has no absolute meaning, that the answer to the question depends on the system we choose.

General relativity theory

The mathematical formulas which make up this general theory are much more difficult than those which are concerned with special relativity. The general relativity theory changes the old ideas about gravitation that have dominated physics since the days of Isaac Newton. According to Newton, two bodies attract each other with a force depending upon their mass and their distance apart. The gravitational influence of a star is felt at the same moment throughout the entire universe, even though it decreases with the distance from the star. But for electromagnetic waves, action spreads through space with great but perfectly definite velocity, that of light. Because of our knowledge of electromagnetic radiation, we tend to reject ideas that disturbances and actions that travel through space have infinite speed. We tend to believe that though they may travel at a very high speed, that speed is not limitless.

Einstein illustrated the basic idea of general relativity with an imaginary experiment. Suppose a lift is at rest in space. If a ball is released within the lift, it will float in space and not fall. If the lift accelerates upward, an observer within the lift will see the ball fall to the floor exactly as it would under the pull of gravity. The ball appears to fall because the floor of the lift—as seen from outside the lift—accelerates upward toward the ball. All the effects we associate with gravity would be seen by the observer in the lift. Einstein called the phenomenon shown in this experiment the *Principle of Equivalence*. This principle states that it makes no difference whether an object is acted on by a gravitational force or is in an accelerated frame of reference. The result in both cases will be the same. From this principle, Einstein reasoned that matter in space distorts or "curves" the frame of reference of space. The result of this curvature is what we experience as gravity. Euclidian or "flat" geometry cannot describe curved space. Thus, Einstein used geometries

called *Riemannian geometries* to describe the effects of gravitation.

According to Newton's theory, a planet moves around the sun because of the gravitational force exerted by the sun. According to the theory of general relativity, the planet chooses the shortest possible path throughout the four-dimensional world, which is deformed by the presence of the sun. This may be compared to the fact that a ship or an aeroplane crossing the ocean follows the section of a circle, rather than a straight line, in order to travel the shortest route between two points. In the same way, a planet or light ray moves along the "shortest" line in its four-dimensional world.

So far, three things have been discovered in which Einstein's theory of general relativity receives experimental proof as opposed to the theories of Newton. These differences are not great, but are measurable. In the first place, according to Newton's theory, the planet Mercury moves in an ellipse about the sun. According to Einstein's theory, Mercury moves along an ellipse, but at the same time the ellipse rotates very slowly in the direction of the planet's motion. The ellipse will turn about forty-three seconds of an arc per century (a complete rotation contains 360 degrees of an arc and $360\times60\times60$ seconds of an arc). This effect is rather small, but it has been observed. Mercury is nearest to the sun and the relativistic effect would be still smaller for other planets.

If we take a picture of part of the heavens during an eclipse of the sun and near the eclipsed sun, and then take another picture of the same part of the heavens a little later, the two photographs will not show identical positions for all the stars. This is so because, according to general relativity, a light ray sent by a star and passing near the rim of the sun is deflected from its original path because the sun's gravity curves space. The effect of gravity on light is also the reason why black holes are invisible. The gravitation in a black hole is so strong that light cannot escape from it.

Physicists have known for more than a hundred years that when some elements are heated to incandescence they give off a pattern of *spectral lines* (coloured lines) which can be examined through a spectroscope. According to the Einstein theory, the wavelength of light emitted from a massive object will become longer because of gravitation. This results in a shift of the spectral lines towards the red end of the spectrum; this type of red shift is called *gravitational red shift.* If we examine the spectral lines of an element on our earth with the spectral lines given off by the same element on the sun or on a star, the spectral lines of the element on the sun or star should be very slightly shifted toward the red end of the spectrum, compared with the spectral lines of the same element on our earth. Experiment has confirmed this shift. In 1960, two American physicists, R. V. Pound and G. A. Rebka, Jr., detected the red shift resulting from the earth's gravitational field. They measured the effect of altitude on the frequency of gamma rays.

Many scientists are doing research in general relativity and studying possible improvements on Einstein's theory. For example, the general theory predicts the existence of waves that "carry" the force of gravity, just as electromagnetic waves carry light. Experimenters have not yet been able to detect these *gravitational waves.* Scientists are also trying to combine electromagnetic and gravitational forces in a theory called the *unified field theory.*

Relativity and other ideas

The ideas of relativity form a framework which can embrace all laws of nature. Relativity has changed the whole philosophical and physical notions of space and time. It has influenced our views and speculation of the distant worlds and stars and of the tiny world of the atom. Some of this speculation is still going on. Does our universe, regarded as a whole, resemble a plane surface or a sphere? It is not possible to answer this question, because there are many different theories and much uncertainty about the distribution of matter in the universe.

All the theories try to describe the universe as a whole and are based upon the mathematical principles of general relativity. According to some theories, a light ray sent from an arbitrary point in space returns, after a very long time interval, to the point of departure, like a traveller in a journey around our earth. Thus, if you were to start from your home and travel into space along a straight line, you would eventually return to the point from which you started. According to other theories, however, a light ray or a traveller would continue an endless journey through space.

In spite of all these successes of the relativity theory, it is not right to say that Newtonian physics is wrong. Newtonian physics holds true if the velocities of the objects being studied are small compared with the velocity of light. Such objects are found every day in our own experience, and therefore classical physics can still be applied to our daily problems. Astronomers have found that Newton's theory of gravitation still holds true in their calculations. But the relativity theory does limit the area to which the Newtonian physics can be successfully applied.

Related articles in *World Book* include:

Black hole	Gravitation
Einstein, Albert	Interferometer
Electromagnetism	Physics (Einstein and relativity)
Fourth dimension	Tachyon
Grand unified theories	

Relaxation. See **Health** (Rest and sleep).

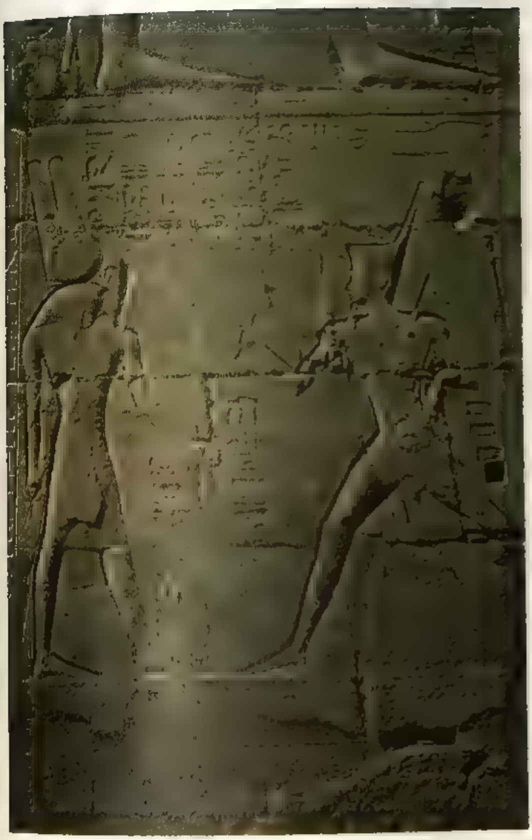
Relaxin. See **Hormone** (Other hormones).

Relief, in art, is sculpture in which the figures or designs project from their background. It differs from *sculpture in the round,* in which the figures stand alone and have three full dimensions. In relief sculpture, the figures are only partly modelled, but they give an illusion of being fully modelled. They may stand out from the background surface, or they may be carved into it. If they are carved into it, the sculpture is called *hollow relief* or *intaglio.*

Relief sculpture may be of three types: high relief; low relief; and half relief, or semirelief. Some relief sculpture combines two or more types.

High relief. Figures modelled in high relief project from their background more than half of their implied thickness. High relief is often called by its Italian name, *alto-rilievo.*

Low relief. Figures that stand out from their background less than half of their suggested thickness are in



A low relief shows a pharaoh offering gifts to Horus, the Egyptian god of light and heaven. Reliefs portraying gods and royalty decorated many ancient Egyptian structures.

Half-relief figures appear in panels on the marble pulpit of the Baptistery of Pisa, Italy. The pulpit, completed by sculptor Nicola Pisano in 1260, also includes realistic carved figures in high relief, extending above the pillars.

Bronze panel (1425 to 1452) by Lorenzo Ghiberti from the east doors of the baptistery in Florence, Italy

High-relief figures in the foreground add drama to a scene from the Old Testament story of Joseph. Italian sculptor Lorenzo Ghiberti designed the background in low relief.

low relief. When the work is well done, they appear to stand out more than they actually do. The frieze of the Parthenon is the most famous example of low-relief sculpture (see **Parthenon**). Sometimes low relief may be nearly flat, as in the design on a coin. Low relief is also known by its French name, *bas-relief.*

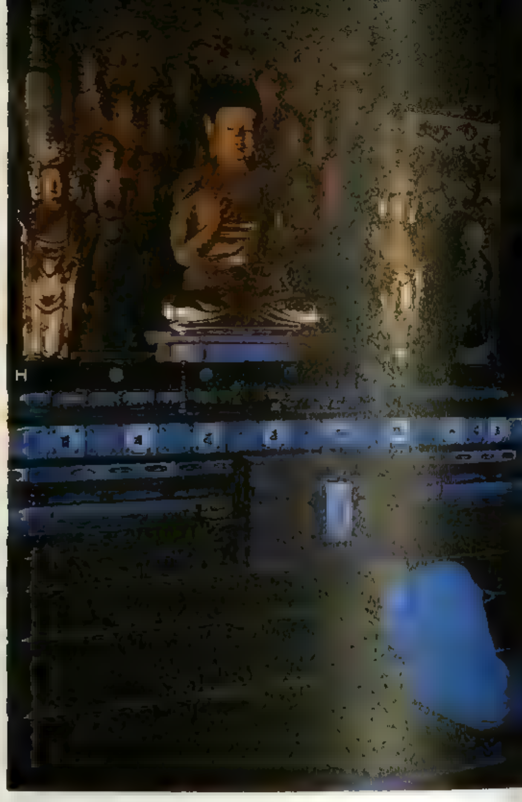
Half relief, or semirelief. Figures in half relief stand out half their thickness. Half relief is a little higher than low relief, but lower than high relief. It is often called by its Italian name, *mezzo-rilievo.*

History. Sculptors have carved figures in relief for thousands of years. Peoples of the stone ages often carved or scratched figures and designs in relief. The Assyrians, Egyptians, and Greeks used all forms of relief sculpture in their palaces and temples.

Relief sculpture is used in many ways today. It is almost the only form used in making coins and medals. As in all sculpture, the subject matter, design, and execution of relief reflect the development of civilization, the religious trends, and the art of the time in which it is made.

See also **Cameo; Engraving; Sculpture** (Kinds of sculpture).

Mass is the most important act of worship in several Christian churches. These worshippers are Roman Catholics.



A Buddhist prays in a temple in South Korea. The centre statue represents Siddhartha Gautama, Buddhism's chief teacher.

Religion

Religion. No simple definition can describe the numerous religions in the world. For many people, religion is an organized system of beliefs, ceremonies, practices, and worship that centre on one supreme God, or the Deity. For many others, religion involves a number of gods, or deities. Some people have a religion in which no specific God or gods are worshipped. There are also people who practise their own religious beliefs in their own personal way, largely independent of organized religion. But almost all people who follow some form of religion believe that a divine power created the world and influences their lives.

People practise religion for several reasons. Many people throughout the world follow a religion simply because it is part of the heritage of their culture, tribe, or family. Religion gives many people a feeling of security because they believe that a divine power watches over them. These people often ask the power for help or protection. Numerous people follow a religion because it promises them salvation and either happiness or the chance to improve themselves in a life after death. For many people, religion brings a sense of individual fulfilment and gives meaning to life. In addition, religion provides answers to such questions as What is the purpose of life? What is the final destiny of a person? What is the difference between right and wrong? and What are one's obligations to other people? Finally, many people follow a religion to enjoy a sense of kinship with their fellow believers.

There are thousands of religions in the world. The eight major ones are Buddhism, Christianity, Confucianism, Hinduism, Islam, Judaism, Shinto, and Taoism. Of these eight religions, Hinduism, Shinto, and Taoism developed over many centuries. Each of the other religions traditionally bases its faith on the life or teachings of specific individuals. They are Prince Siddhartha Gautama, who became known as Gautama Buddha, for Buddhism; Jesus Christ for Christianity; Confucius for Confucianism; Muhammad for Islam; and Abraham and Moses for Judaism.

The religions that trace their history to individuals follow a general pattern of development. During the individual's lifetime or soon after his death, a distinctive system of worship ceremonies grew up around his life and teachings. This system, called a *cult,* became the basis of the religion. The heart of the cult is the teachings. In addition to inspiring worship, the individual represents an ideal way of life that followers try to imitate.

Religion has been one of the most powerful forces in history. The teachings of religions have shaped the lives of people since prehistoric times. Judaism, Islam, and especially Christianity have been major influences in the formation of Western culture. These three faiths, particularly Islam, have also played a crucial role in the development of Middle Eastern culture. The cultures of Asia have been shaped by Buddhism, Confucianism, Hinduism, Shinto, and Taoism. Most religions have been influenced by older religions.

African San go into a trance while dancing near a sacred fire. They believe the fire's heat gives them the power to heal.

Religion has been a supreme source of inspiration in the arts. Some of the most beautiful buildings in the world are houses of worship. Much of the world's greatest music is religious. Religious stories have provided countless subjects for paintings, sculptures, literature, dances, and films.

This article describes the chief characteristics of religion. It also examines the origin of religion in prehistoric times. In addition, the article describes the organization of the world's eight major religions and briefly relates the history of each. Many separate *World Book* articles provide information on topics related to religion. For a list of these articles, see the *Related articles* at the end of this article.

Chief characteristics of religion

Most of the leading religions throughout history have shared characteristics. The chief characteristics include (1) belief in a deity or in a power beyond the individual, (2) a *doctrine* (accepted teaching) of salvation, (3) a code of conduct, (4) the use of sacred stories, and (5) religious *rituals* (acts and ceremonies).

The essential qualities of a religion are maintained and passed from generation to generation by sources, called *authority,* which the followers accept as sacred. The most important religious authorities are writings known as *scriptures.* Scriptures include the Bibles of Christians and Jews, the Quran of Muslims, and the Vedas of Hindus. Religious authority also comes from the writings of saints and other holy persons and from decisions by religious councils and leaders. Unwritten customs and laws known as *traditions* also form a basic part of authority.

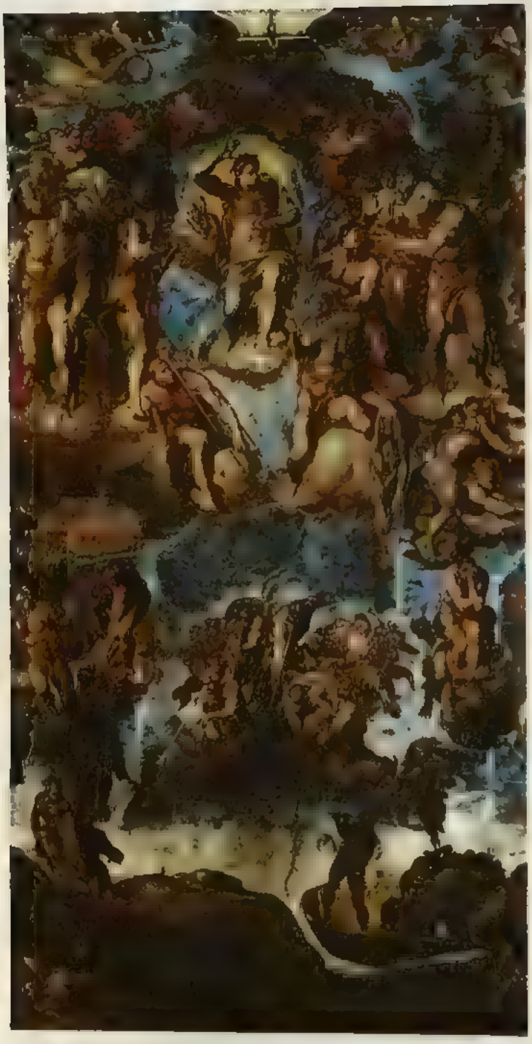
Belief in a deity. There are three main philosophical views regarding the existence of a deity. *Atheists* believe that no deity exists. *Theists* believe in a deity or deities. *Agnostics* say that the existence of a deity cannot be proved or disproved. Most of the major religions are theistic. They teach that deities govern or greatly influence the actions of human beings as well as events in nature. Confucianism is the most important atheistic religion.

Religions that acknowledge only one true God are *monotheistic.* Judaism, Christianity, and Islam are examples of monotheistic religions. A religion that has a number of deities is *polytheistic.* The ancient Greeks and Romans had polytheistic religions. Each of their many gods and goddesses had one or more special areas of influence. For example, Aphrodite was the Greek goddess of love, and Mars was the Roman god of war. In *henotheistic* religions, the worship of a supreme Deity does not deny the existence and power of other deities. For example, Hinduism teaches that a world spirit called Brahman is the supreme power. But Hindus also serve numerous other gods and goddesses. Many tribes in Africa and the Pacific Islands also worship a supreme power as well as many other deities.

The followers of some religions have deities that are or were people or that are images of people. The ancient Egyptians considered their pharaohs to be living gods. Before World War II (1939-1945), the Japanese honoured their emperor as divine. Taoists have deities that look and act like human beings. They also worship some deities that were human beings and became gods or goddesses after death.

Many people worship nature deities—that is, deities that dwell in nature or control various aspects of nature.

Honouring the saint Gomateswara, followers of Jainism bathe a huge granite figure with a sacred liquid. Jain pilgrims travel to Mysore, India, for the ceremony every 12 years.



Detail of a fresco (1541) by Michelangelo; Sistine Chapel, The Vatican, Rome

Salvation from eternal punishment is the goal of many religions. This painting represents the Christian belief in the Last Judgment, when every person will either be granted happiness in heaven, *top,* or be condemned to suffering in hell, *bottom.*

The Chinese in particular have worshipped gods of the soil and grain. Followers of Shinto worship *kami,* spirits that live in nature. Many American Indian tribes worshipped a *spirit power,* a mysterious, magic force in nature.

A doctrine of salvation. Among the major religions, Christianity, Islam, Buddhism, and Hinduism teach a doctrine of salvation. They stress that salvation is the highest goal of the faithful and one that all followers should try to achieve. Religions differ, however, in what salvation is and in how it can be gained.

A doctrine of salvation is based on the belief that individuals are in some danger from which they must be saved. The danger may be the threat of physical misfortune in this world, such as a disease. Christianity and several other major religions teach that the danger is spiritual and is centred in each person's soul. The danger to the soul pertains mainly to life after death. If a person is saved, the soul enters a state of eternal happiness, often called heaven. If the person is not saved, the soul may spend eternity in a state of punishment, which is often called hell.

Most religions teach that a person gains salvation by finding release from certain obstacles that block human fulfilment. In Christianity, the obstacles are sin and its effects. In most Asian religions, the obstacles are worldly desires and attachment to worldly things. Salvation in these religions depends on whether believers can free themselves from the obstacles with the aid of a saviour. The saviour may be the individual on whose teachings the religion is based, a god, or some other divine figure. People must accept the saviour. They must also accept certain teachings, perform certain ceremonies, and abide by certain rules of moral conduct—all of which were inspired by the saviour.

Some religions consider salvation to be a gift from the Deity or deities. For example, many Christian denominations believe that individuals are saved by the grace of God and not by their own merit.

Most religions teach that salvation comes only once and is eternal. According to Buddhism and Hinduism, the soul lives on after the death of the body and is reborn in another body. This cycle of rebirths is called *reincarnation.* The doctrine of *karma* is closely related to reincarnation. According to this doctrine, a person's actions, thoughts, and words determine the kind of animal or human body the soul will live in during the next reincarnation. The process of reincarnation continues until, through good deeds and moral conduct, a person finally achieves a state of spiritual perfection, which is salvation. Buddhists call this state *nirvana,* and Hindus call it *moksha.*

A code of conduct is a set of moral teachings and values that all religions have in some form. Such a code, or *ethic,* tells believers how to conduct their lives. It instructs them how to act toward the deity and toward one another. Religious codes of conduct differ in many ways, but most agree on several major themes. For example, they stress some form of the *golden rule,* which states that believers should treat others as they would like to be treated themselves. A religion's code of conduct also may determine such matters as whom believers may marry, what jobs they may hold, and what kinds of foods they may eat.

The use of sacred stories. For thousands of years, followers of religions have believed in sacred stories, called *myths.* Religious leaders often used these stories to dramatize the teachings of their faith.

Originally, people told myths to describe how the sacred powers directly influenced the world. As the stories developed, they showed how some feature or event in the world was indirectly caused by the sacred powers. Many stories described the creation of the world. Others told how the human race or a particular people began. Some of the stories tried to explain the cause of natural occurrences, such as thunderstorms or the changes in seasons.

Today, there are scientific explanations for many of the subjects dealt with in sacred stories. But some religious groups still insist that the stories are true in every detail. Other groups believe only in the message con-

Hindus bathe in the Ganges River, *left,* to purify their bodies. Millions of Hindus make periodic pilgrimages to their holy city of Varanasi, India, to be purified in the sacred river.

tained in the stories, not in the specific details. Still other religious groups regard sacred stories as symbolic expressions of the ideals and values of their faith.

Religious rituals include the acts and ceremonies by which believers appeal to and serve God, deities, or other sacred powers. Some rituals are performed by individuals alone, and others by groups of worshippers. Important rituals are performed according to a schedule and are repeated regularly. The performance of a ritual is often called a *service.*

The most common ritual is prayer. Through prayer, a believer or someone on behalf of believers addresses words and thoughts to an object of worship. Prayer includes requests, expressions of thanksgiving, confessions of sins, and praise. Most major religions have a daily schedule of prayer. Meditation, a spiritual exercise much like prayer, is important in Asian religions. Buddhist monks try to be masters of meditation.

Many religions have rituals intended to purify the body. For example, Hindus consider the waters of the Ganges River in India to be sacred. Every year, millions of Hindus purify their bodies by bathing in the river, especially at the holy city of Varanasi.

In some religions, *pilgrimages* are significant rituals. Pilgrimages are journeys to the sites of holy objects or to places credited with miraculous healing powers. Believers also make pilgrimages to sacred places, such as the birthplace or tomb of an important member of their faith. All devout Muslims hope to make a pilgrimage to Mecca, the birthplace of Muhammad.

Many rituals are scheduled at certain times of the day, week, or year. Various religions have services at sunrise, in the morning, at sunset, and in the evening. The different religions have special services to mark the beginning of a new year. Many religions celebrate springtime, harvest time, and the new or full moon.

Many rituals commemorate events in the history of religions. For example, the Jewish festival of Passover re-

Jews celebrate the Passover in memory of the ancient Israelites' escape from Egyptian slavery. The highlight of this annual festival is a ceremonial feast called the *Seder, left.*

The ceremony of baptism marks the entrance of a person into Christianity. The Lutheran minister shown above has baptized the baby by placing a small quantity of water on its head.

calls the meal that the Israelites ate just before their departure from slavery in Egypt. Various Christian celebrations of Holy Communion are related to the last meal that Jesus shared with His disciples before His death.

Rituals also mark important events in a person's life. Various religious ceremonies make sacred occasions of birth, marriage, and death. Rituals serve to accept young people into the religion and into religious societies. In Judaism, the ritual of circumcision is performed on male infants. Some Christians baptize babies soon after birth. Other Christians baptize only youths or adults.

How the major religions are organized

The organization of the world's major religions ranges from simple to complex. Many religions have spiritual leaders, often called the *clergy.* These leaders have the authority and responsibility to conduct religious services, to advise or command believers, and to govern the religious organization at various levels. In some religions, the *laity*—that is, the believers who are not members of the clergy—also have important organizational roles.

In many countries, there is a *state* (official or favoured) religion. For example, Islam is the state religion of Iran. Lutheranism is the state religion of Sweden, and Buddhism is the state religion of Thailand.

Judaism has no one person as its head. Each local congregation supervises its own affairs, usually under the leadership of a rabbi. Israel and a few other countries have chief rabbis. These rabbis are scholars who serve as the top judges of religious law.

Christian *denominations* (groups) are organized in various ways. In the Roman Catholic Church, believers are organized into districts called *parishes,* which belong to larger districts called *dioceses.* Dioceses, in turn, belong to *provinces.* The main diocese in each province is called an *archdiocese.* Pastors preside over parishes, bishops over dioceses, and archbishops over archdioceses. The pope presides over the entire Roman Catholic Church with the advice and assistance of high officials called *cardinals.* Some Protestant denominations are governed by similar patterns of *hierarchies* (levels of authority). Other denominations are governed by boards of the clergy and laity or by local congregations.

Confucianism and Islam have no clergy. Leadership is provided by scholars who interpret the teachings of the faith. In Shinto and Taoism, the basic organizational unit is the priesthood. In Buddhism, the chief organizational unit is an order of monks called the *sangha.* The monks serve as advisers and teachers and play a vital part in everyday life in Buddhist countries. In some Buddhist countries, the head of state is also the leader of the national order of monks.

Hinduism has no consistent pattern of organization. There are no congregations or parishes. Hindus tend to worship individually or in families. Services in temples are performed by the Brahmans, the highest Hindu *caste* (social class). In some areas, the Brahmans occasionally serve as a kind of royal priesthood.

The origin of religion

The earliest recorded evidence of religious activity dates from only about 60,000 B.C. However, anthropologists and historians of religion believe that some form of religion has been practised since people first appeared on the earth about 2 million years ago.

Experts think prehistoric religions arose out of fear and wonder about natural events, such as the occurrence of storms and earthquakes and the birth of babies

Major religions of the world

*A system of beliefs that includes Confucianism and Taoism.
Figures are for 1993.
Source: David B. Barrett, editor, *World Christian Encyclopedia;* American Jewish Committee.

Drawing based on engravings on the wall of a cave in southern France; Musée de l'Homme, Paris

Prehistoric people performed religious ceremonies to ensure a sufficient food supply. The prehistoric artist who drew this scene may have believed that it would bring success in hunting.

and animals. To explain why someone died, people credited supernatural powers greater than themselves or greater than the world around them.

Prehistoric people centred their religious activities on the most important elements of their existence, such as the prosperity of their tribe and getting enough food to survive. They often placed food, ornaments, and tools in graves. They believed that these items would be useful to or desired by dead people. Prehistoric people drew pictures and performed dances that were intended to promote the fertility of women and animals and to ensure good hunting. They also made sacrifices for the same reasons.

Certain scholars have developed theories on how religion began in prehistoric times. No one theory has been accepted by all scholars, but each major theory has contributed to an understanding of the subject. Leading theories were developed by Sir Edward Burnett Tylor, Friedrich Max Müller, and Rudolf Otto.

Tylor's theory. Tylor was a British anthropologist of the 1800's. According to Tylor's theory, early people believed that spirits dwelled in and controlled all things in nature. For example, they thought that spirits lived in such objects or forces as plants, the wind, volcanoes, and the sun. Tylor called the spirits *animae,* and his theory became known as *animism.*

Prehistoric people, Tylor said, explained such occurrences as windstorms and the change from day to night as the actions of the spirits. Because many of the objects and forces were impressive or very powerful, people started to worship their spirits. According to Tylor, religion originated in this worship.

Müller's theory. Müller, a German-born language scholar of the 1800's, is often considered the first historian of religion. Müller agreed with Tylor that religion began as spirit worship. But he rejected Tylor's view that the earliest people believed spirits dwelled in nature. Instead, Müller suggested that prehistoric people thought that the forces of nature themselves had human qualities, such as good or bad temper. People thus transformed these forces into deities. In this way, Müller explained the earliest belief in gods.

Otto's theory. Otto was a German scholar of religion of the early 1900's. Otto believed that an awareness of holiness and mystery lies at the heart of religious experience and is therefore the basis for all religions. In his view, all human beings possess the capacity for awe and recognize the power of the sacred. For Otto, the holy is the true, the good, and the beautiful, a representation of a basic and universal aspect of being human.

History of the world's major religions

The eight major religions practised in the world today were either founded or developed their basic form between about 600 B.C. and A.D. 600. The following discussion traces the history of each of these religions.

Judaism began among the ancient Israelites in the Middle East. Jewish tradition traces the roots of the religion back to Abraham, who lived between about 1800 and 1500 B.C. His grandson Jacob, who was also called Israel, had 12 sons. They founded the 12 tribes that became the Israelites. Over a period of time, many Israelites settled in Egypt, where they eventually became slaves. During the 1200's B.C., the great lawgiver Moses led them out of Egypt to Canaan (Palestine). Jewish tradition also says that Moses received from God the first five books of the Bible, which are called the Pentateuch or the Torah. These books, sometimes known as the Mosaic Law, have been the basis of the Jewish religion.

Judaism was the first religion to teach the belief in one God. Some scholars say that the Jews became monotheistic during the time of Moses. But most scholars believe that Jewish *prophets* (religious teachers and thinkers) converted the Jews to monotheism by about 600 B.C.

Miniature (about 1300) by an unknown German artist from the Regensburg Pentateuch; Israel Museum, Jerusalem

The Ten Commandments contain the basic laws of Judaism and Christianity. In this picture, God gives the commandments to the Jewish leader Moses, who presents them to the Jews.

Giant Buddha in the Ling Yin Temple, Hang-chou, China

Buddha preached that people can gain *nirvana,* or salvation, by freeing themselves from worldly attachments and desires. Buddhism began in India and spread to China and other Asian lands.

During Biblical times, first the Assyrians, then the Babylonians, and finally the Romans conquered the Israelites. Many Jews were driven into exile. Over the centuries, the Jewish people settled in various parts of the Middle East and in European countries. Everywhere, they were always a religious minority, and they were often persecuted for their faith.

After about 1800, Jews divided into three general groups—Orthodox, Conservative, and Reform. Orthodox Jews observed rituals in traditional ways. Conservative and Reform Jews modernized certain practices. Most eastern European Jews followed Orthodox Judaism, and most western European and North American Jews followed Conservative or Reform Judaism.

In the 1930's, the German dictator Adolf Hitler and his Nazi Party began a vicious campaign against Jews. By 1945, the Nazis had killed about 6 million of the 8 million to 9 million Jews in Europe. Many of the survivors joined Jews living in Palestine. Together, they established the state of Israel in 1948 under the sponsorship of the United Nations (UN). It was the first homeland Jews had known since Biblical times.

Hinduism began about 1500 B.C. At that time, a central Asian people called the Aryans invaded and conquered India. The Aryan culture gradually combined with the culture of a native people known as the Dravidians. Hinduism developed from a blend of the two cultures.

The oldest Hindu scriptures are the Vedas. They were composed over a period of 1,000 years, beginning about 1000 B.C. This stage in Hindu history is often called the Vedic period. During Vedic times, believers worshipped a number of nature deities. At the end of the period, the doctrines of reincarnation and karma were adopted.

By the 500's B.C., Hinduism was splitting into various schools of thought. Two of these schools—Buddhism and Jainism—became new religions. The Hindu schools further split into smaller *sects.* Today, Hinduism includes a great number of schools and sects. Many of the sects were formed by saints or *gurus* (spiritual teachers). Each sect has its own philosophy and form of worship. But they all accept basic Hindu doctrines.

Buddhism developed in India during the late 500's B.C. from the teachings of a prince named Siddhartha Gautama. Gautama became known as Gautama *Buddha,* meaning *Enlightened One.* Buddhism was partly a rebellion against certain features of Hinduism. Buddhism opposed the Hindu worship of many deities, the Hindu emphasis on caste and the supernatural, and the power of the Hindu priest class.

Buddha taught that people should devote themselves to finding release from the suffering of life. Through this release, people would gain *nirvana,* a state of perfect peace and happiness. To achieve nirvana, they had to free themselves from all worldly desires and attachments to worldly things. Buddha taught that nirvana could be gained by following the *Middle Way* between the extremes of severe self-denial and uncontrolled passion. As Buddha preached, he attracted a growing number of followers. By the time of his death, about 483 B.C., Buddhism was firmly established in India.

Buddhism spread into central Asia. By the end of the A.D. 100's, it had been introduced into China. Buddhism swept through much of China from the 300's to the 500's, challenging the native Chinese religions of Confucianism and Taoism in popularity. In the 500's, Chinese Buddhism spread to Korea and Japan. Buddhism became the chief Japanese religion for the next 1,000 years.

Early in its history, Buddhism divided into two forms, Theravada and Mahayana. Today, Theravada Buddhism is strongest in Burma, Cambodia, Laos, Sri Lanka, and Thailand. Most Mahayana Buddhists live in Japan, Korea, Mongolia, Nepal, Tibet, Vietnam, and scattered parts of India and Russia.

Confucianism is a Chinese religion based on the teachings of Confucius, a philosopher who died about 479 B.C. Confucianism has no organization or clergy. It does not teach a belief in a deity or in the existence of life after death. Confucianism stresses moral and political ideas. It emphasizes respect for ancestors and government authority and teaches that rulers must govern according to high moral standards.

Confucianism, Buddhism, and Taoism have been the major religions in China. But Confucianism has had the greatest impact on Chinese society. It was the state religion of China from the 100's B.C. until the A.D. 1900's. Chinese rulers approved of its emphasis on respect for authority and dedication to public service. Confucian scriptures called the Five Classics and Four Books served as the foundation of the Chinese educational system for centuries. Candidates applying for government jobs had to pass examinations based on these scriptures.

Beginning in the 1000's, a more philosophical approach to Confucianism known as Neo-Confucianism became widely popular. Neo-Confucianism also influenced Japanese moral codes and philosophy from the 1600's through to the 1800's.

In 1949, the Chinese Communists gained control of China. The government officially condemned Confucianism, as well as other religions. As a result, most follow-

Confucius' birthday is a holiday in Taiwan. The men in the temple shown at the left help perform special birthday ceremonies. Followers of Confucius placed the food offerings before the altar.

ers lived outside mainland China, especially in Taiwan. In the late 1970's, however, the Communist government relaxed its policy against religion, and so Confucianism has enjoyed a revival on the mainland.

Taoism, like Confucianism, is a native Chinese religion. Its roots go back to the earliest history of China. However, Taoism did not begin to develop as an organized religion until the 100's B.C.

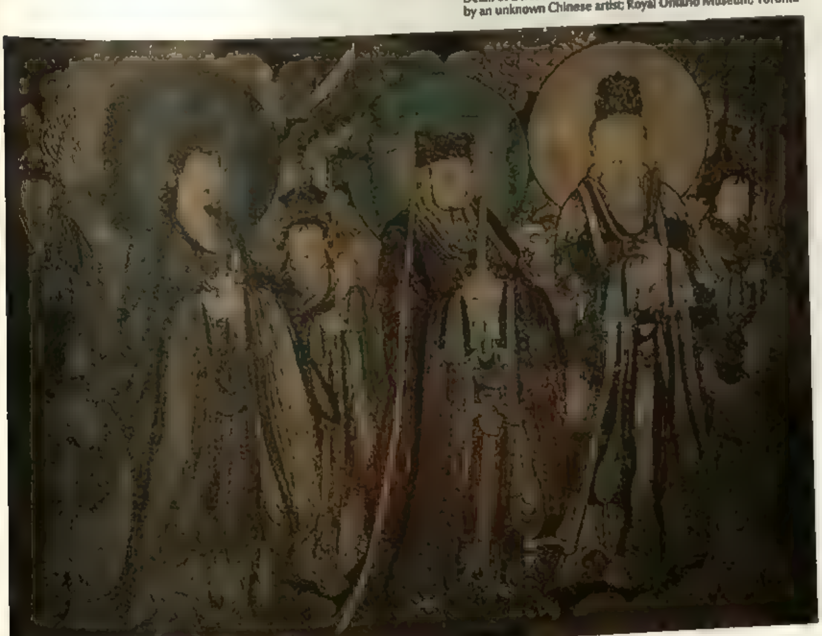
Taoism teaches that everyone should try to achieve two goals, happiness and immortality. The religion has many practices and ceremonies intended to help people. They include prayer, magic, special diets, breath control, meditation, and recitation of scriptures. Taoists also believe in astrology, fortunetelling, witchcraft, and communication with the spirits of the dead.

Taoists worship more deities than do the followers of almost any other religion. Some deities are ancestors, and others are the spirits of famous people.

During its early history, Taoism borrowed heavily from Buddhism. Many Taoist deities, temples, and ceremonies show the influence of Buddhism. By the A.D. 1000's, Taoism had divided into many sects. The members of some of these sects withdrew from everyday life to meditate and study in monasteries. Other sects were based in temples. The temple priests passed their positions on to their children. The members of this hereditary priesthood lived among the common people. They gained a reputation as highly skilled magicians who could tell the future and protect believers from illness, accidents, and other misfortune.

Chinese governments of the early and mid-1900's opposed Taoism, claiming it was based on superstition. Today, the Chinese government permits the practice of the religion and followers are gradually increasing in number. In addition, Taoists remain active in Chinese societies outside China, especially in Taiwan.

Detail of a fresco (late 1200's or early 1300's) by an unknown Chinese artist; Royal Ontario Museum, Toronto



Taoist deities outnumber those of almost every other religion. They include the Jade Emperor, *centre,* who rules the earth, and the Empress of Heaven, *left,* who rules heaven. The figure at the right is Laozi, an ancient Chinese philosopher who is considered a founder of Taoism.

A Shinto festival attracts thousands of believers to the Meiji shrine in Tokyo. Parents visit the shrine with their children to thank the gods for their children's good health. They also pray for good fortune for their children. The large wooden gate, or arch, called a *torii,* is the symbol of Shinto.

Shinto is the native religion of Japan. According to Shinto mythology, deities created Japan and its people. Until the mid-1900's, the Japanese worshipped their emperor as a direct descendant of Amaterasu-Omikami, the sun goddess and most important Shinto deity.

Shinto developed from native folk beliefs. Followers worship spirits and demons that live in animals and in mountains, trees, and other parts of nature. In early Japanese history, Shinto was devoted chiefly to this form of nature worship. Beginning in the A.D. 500's, Buddhism influenced the development of Shinto. Confucianism became influential in the A.D. 600's. Both of these religions helped shape Shinto rituals and doctrines. Buddhist and Shinto services have occasionally been held in the same temples. But unlike Buddhism, Shinto never developed strong doctrines on either salvation or life after death.

During the late 1800's, the Japanese government sponsored a form of Shinto called State Shinto. State Shinto stressed patriotic religious ceremonies and the divine origins of the emperor. In 1882, the government officially separated Shinto into State Shinto and Sectarian Shinto. The government administered State Shinto. Sectarian Shinto was popular among the common people. After World War II, the Japanese government abol-

Detail of a mosaic (about A.D. 500) by an unknown Italian artist; Sant' Apollinare Nuovo, Ravenna, Italy

Jesus Christ founded Christianity. Jesus, shown with a halo in this picture, calls two fishermen, Andrew and Peter, to become His followers. These two men were the first of the group that became known as *apostles.*

ished State Shinto and the doctrine that the emperor was divine.

Christianity is based on the life and teachings of Jesus Christ in Palestine. Most Christians believe that God sent Jesus to the world as the Saviour. Christianity teaches that humanity can achieve salvation through Jesus.

After Jesus' Crucifixion, a number of His followers spread His teachings. One of the most important of these followers was Saint Paul. After Paul's death, about A.D. 67, Christianity continued to grow in spite of persecution by the Romans, whose empire covered most of Europe, the Middle East, and northern Africa. In the early 300's, the Roman emperor Constantine the Great became a Christian. By the late 300's, Christianity was widely practised throughout the empire.

During the Middle Ages, Christian missionaries converted many European barbarian tribes, which led to the Christian church's dominant influence on European life for centuries. For many years, a split had been developing between Christians in western Europe and those in eastern Europe and western Asia. The split finally occurred in the 1000's. The churches in Greece, Russia, and other parts of eastern Europe and western Asia became known as the Eastern Orthodox Churches. The church in western Europe became known as the Roman Catholic Church.

In the 1500's, a religious movement called the Reformation divided western Christianity into several bodies. Most southern Europeans remained Roman Catholics. A great number of northern Europeans, known as Protestants, formed new churches. The largest include the Baptist, Congregationalist, Episcopal, Lutheran, Methodist, and Presbyterian churches.

Beginning in the 1500's, Catholic missionaries converted many people in Africa, Asia, and the Americas to Christianity. Protestant missionaries became active in the 1600's and made converts in the Far East, Africa, and North America.

Islam is based on the life and teachings of the prophet Muhammad, who lived in Arabia during the early A.D. 600's. Before Muhammad's time, the people in the region worshipped Allah (God) as well as other deities. But Muhammad said Allah was the only God.

According to Islamic tradition, Muhammad had the first of several visions about 610. The vision occurred while Muhammad was meditating in a cave on Mount Hira, a hill near his birthplace of Mecca, in what is now Saudi Arabia. The vision commanded Muhammad to preach the message of Allah to the people of his country. He began preaching in Mecca. A tribe called the Quraysh controlled Mecca and opposed Muhammad. To avoid persecution by the Quraysh, Muhammad fled to the city of Medina. Muhammad's journey from Mecca to Medina is called the *Hegira* and is one of the central events in the founding of Islam.

In 630, Muhammad led an army to Mecca. He offered the people of the city generous peace terms. As a result, his forces were able to take the city with little resistance. Muhammad made Mecca the sacred city and centre of Islam.

After Muhammad's death in 632, his friend and disciple Abu Bakr became the first *caliph* (leader) of Islam. Abu Bakr defeated a rebellion against his rule by Arabian tribes and began a campaign of religious conquest outside Arabia. Succeeding caliphs continued Abu Bakr's conquests. Within 100 years of Muhammad's death, Islam had spread throughout the Middle East, across northern Africa, and into Spain. In 732, Muslim and Christian armies fought a major battle near Tours, France. The Muslims were defeated, and western Europe remained Christian.

A Muslim reads the Quran at a temple in Mecca, the holiest city of Islam. The Islamic religion is based on the teachings of Muhammad, a prophet who preached during the A.D. 600's.

Muslim missionaries and traders carried Islam to India and other parts of Asia. From the 1000's to the 1200's, Islam spread into western Africa. Today, Islam is the major religion of nearly all countries in northern Africa and the Middle East. It is also the chief religion in Bangladesh, Indonesia, Malaysia, and Pakistan.

Religion today

Religion in the West has been severely criticized in the 1900's. Numerous critics charge that many religious doctrines have become dry and uninspiring and no longer satisfy spiritual needs. Critics have also claimed that traditional religions fail to deal with current social issues and that they support outdated moral attitudes. Some religious groups have tried to meet society's needs and problems. For example, most religions have traditionally prohibited the ordination of women as clergy and from other leadership positions. For many

Hindu activists demand the right to build a temple at the claimed birthplace of the god Rama in Ayodhya, Uttar Pradesh, India. Their actions, in 1992, angered Muslims but were supported by devout Hindus.

women, these limitations left their spiritual needs unfulfilled. Many Christian denominations and groups in Judaism now allow women roles which are equal to those of men. Christians also see the *ecumenical movement* in Christianity as a positive step toward bringing a spirit of cooperation and renewal to Western religion (see **Protestantism**).

Many people throughout the world have, since the mid-1900's, turned to a stricter interpretation of their religion. They look for the *fundamental* (basic) principles of their belief and hope to live their lives by such principles. In Christian denominations, this means accepting every word of the Bible as divinely inspired. Christian *fundamentalists* (strict observers) have had great social and political influence in the United States. Christian fundamentalist leaders include television evangelists.

Hindu fundamentalists have gained political importance in India. In 1992, extremists who were responsible for the destruction of a Muslim mosque built on the remains of a Hindu shrine in the town of Ayodhya, gained many followers. Their action angered local Muslims. The meetings of such extremists have stirred up riots.

Islam and Judaism have also developed strong fundamentalist movements, both in the West and in the Middle East. Islamic *revivalists* (people who seek to reawaken the faith) have achieved political influence in such countries as Algeria, Egypt, and Iran. Hasidism is gaining a large number of followers among Jews in Israel and the United States (see **Hasidism**).

Some of the strict observers of any religion are unable to accept the beliefs of others. Many violent confrontations, even wars, have come about as a result of religious intolerance.

Seeking a more peaceful way of life, some people in the West have turned to new religions or movements, or to religions whose origins are in the East. A large number of people have sought fulfilment in the teachings of Asian religions. Some of these people have been attracted to *Zen,* a form of Buddhism that emphasizes meditation.

Some Westerners have turned to other kinds of supernatural teachings, some to astrology, spiritualism, or paganism. Astrology is based on the belief that the planets and other heavenly bodies influence human affairs. Spiritualists believe that it is possible to communicate with the spirits of the dead. Pagans find inspiration from a range of ancient religious cults.

Related articles. See the *Religion* section of the articles on various countries, such as **Canada** (Religion); **Israel** (Religion). Additional related articles in ***World Book*** include:

Christianity

See the following articles and their lists of *Related articles:*

Bible	Pope	Roman Catholic Church
Cardinal	Protestantism	Saint
Christianity	Religious life	

Other religions

Bahá'ís	Judaism
Buddhism	Rastafarians
Confucianism	Shinto
Hinduism	Sikhism
Islam	Taoism
Jainism	Zoroastrianism

Founders of religions

Bahá'u'lláh	Confucius	Muhammad
Buddha	Jesus Christ	

Deities

For lists of articles on deities of early religions, see the *Related articles* with **Mythology**. See also the following articles:

Allah	Elohim	Jehovah	Shiva
Brahman	God	Mithra	Vishnu

Beliefs and doctrines

Agnosticism	Heaven	Predestination
Ancestor worship	Hell	Purgatory
Atheism	Immaculate Conception	Resurrection
Deism	Immortality	Spiritualism
Devil	Messiah	Theism
Ethics	Pantheism	Theology
Foreordination	Philosophy (Philosophy and religion)	Theosophy
Free will	Polytheism	Transfiguration
Gnosticism		Transubstantiation
Golden rule		Trinity

Sacred writings

Bhagavad-Gita	Quran	Talmud
Bible	Ramayana	Vedas
Mahabharata		

Officials and organization

Abbot	Cardinal	Dervish
Archbishop	Chaplain	Fakir
Bishop	Deacon	

Friar
High priest
Levites
Magi
Metropolitan
Minister
Missionary
Monk
Nun
Patriarch
Pope
Priest
Rabbi
Sanhedrin

Religious practices

Anointing of the sick
Baptism
Bar mitzvah
Catechism
Communion
Confirmation
Coronation
Drama (Medieval drama; Religious plays)
Exorcism
Fast
Feasts and festivals
Funeral customs
Grace
Hajj
Hymn
Kosher
Liturgy
Marriage
Mass
Prayer
Sacrament

Ancient and primitive religions

Animal worship
Animism
Assyria (Religion)
Aztec (Religion)
Babylonia (Religion)
Devil worship
Egypt, Ancient (Religion)
Eskimo (Religion)
Fetish
Fire worship
Greece, Ancient (Religion)
Inca (Religion)
Indian, American (Religion)
Maya (Religion)
Mysteries
Mythology
Nature worship
Pacific Islands (Religions)
Persia, Ancient (Religion)
Phoenicia (Religion)
Prehistoric people (Religion and art)
Rome, Ancient (Religion)
Sun worship
Taboo
Voodoo

Other related articles

Astrology
Cult
Druses
Freedom of religion
Heresy
Hermit
Idolatry
Magic
Müller, Max
Mysticism
Occultism
Painting (Religious subjects; pictures)
Revivalism
Theocracy
Tylor, Sir Edward Burnett

Outline

I. Chief characteristics of religion
- A. Belief in a deity
- B. A doctrine of salvation
- C. A code of conduct
- D. The use of sacred stories
- E. Religious rituals

II. How the major religions are organized

III. The origin of religion
- A. Tylor's theory
- B. Müller's theory
- C. Otto's theory

IV. History of the world's major religions
- A. Judaism
- B. Hinduism
- C. Buddhism
- D. Confucianism
- E. Taoism
- F. Shinto
- G. Christianity
- H. Islam

V. Religion today

Questions

How long have people practised some form of religion?
What is the Pentateuch? The Quran? The Five Classics and Four Books?
Who founded Buddhism? Christianity?
What is *charismatic Christianity*?
What are the doctrines of *reincarnation* and *karma*?
What are some reasons people practise religion?
How do *monotheistic, polytheistic,* and *henotheistic* religions differ?
What is the theory of *animism*?
Who is the most important Shinto deity?
What is the most common religious ritual?

Religion, Freedom of. See Freedom of religion.

Religious festivals. For examples, see Feasts and festivals and its list of *Related articles.*

Religious freedom. See Freedom of religion.

Religious life is a term for the way of life that some people choose for becoming as holy as possible and for being of the greatest possible service to others. Those who adopt this manner of life are called monks, nuns, brothers or sisters—or simply religious. Some may be priests or ministers. But most followers of the religious life are not members of the clergy.

Followers of the religious life devote themselves exclusively to holiness and service. Unlike ascetics and hermits, who also strive for holiness, they belong to religious orders (see **Asceticism; Hermit**). The members of many orders live together in a community under a religious superior. These communities are called convents, though those where monks live may be known as monasteries, and most nuns live in nunneries. After one or more years of training and testing, candidates are admitted into the community. In most cases, the candidates vow to stay until they die. Generally, a final commitment is made only after several years of living under temporary vows or promises.

All religious communities were founded to advance the spiritual life of their members. *Contemplative* orders concentrate on this role and have an organized daily routine with ascetic practices and many hours of prayer. *Active* communities engage in social and spiritual work in schools, hospitals, and orphanages. But even the most active community is basically dedicated to promoting the holiness of its members.

Christian communities

Religious life among Christians started with the practice and teachings of Jesus. His voluntary poverty, His

The religious life makes great demands on its followers for discipline, holiness, and service. Many give their lives to working for others, like this nun in a mission school in Bolivia.

celibacy (remaining unmarried), and His obedience to God's will became the pattern for the religious life.

The Roman Catholic Church. Persecution in the early Christian church prevented the development of organized religious orders in the Roman Empire. However, many hermits practised poverty, remained unmarried, and lived alone in the desert. St. Paul the Hermit and St. Anthony of Thebes were dominant figures in this early stage of the religious life. Both lived in Egypt.

In the early 300's, St. Pachomius organized a religious community in south Egypt. He wrote a *rule* (programme of life) for monks who wished to live together under a superior. Shortly before his death, there were 40 monasteries with 2,000 monks under his direction. Later in the 300's, St. Basil of Caesarea adopted the rule of Pachomius and made his monasteries in Asia Minor homes of charity. The monasteries included orphanages, hospitals, farms, and places of rest.

St. Benedict of Nursia was the father of Christian monasticism in the West. His policies of the 500's became the pattern for religious life in Europe and America. The Benedictine approach emphasized attachment to a single monastery, community living, and labour. Eastern monasticism, on the other hand, stressed austere physical living and severe discipline. Today, Eastern Orthodox religious life still favours the pattern of St. Pachomius and St. Basil, and the Roman Catholic Church prefers that of St. Benedict.

During the early 1200's, St. Francis of Assisi began a new practice in religious life by encouraging his followers to travel about the countryside, preaching and helping the needy. Also around 1200, St. Dominic established the Order of Preachers to teach in schools and colleges. In 1534, St. Ignatius Loyola founded the Jesuits "to extend the Kingdom of Christ" to all parts of the world. Early Jesuits included missionaries such as St. Francis Xavier in India, and such explorers as Jacques Marquette in America.

During the 1500's and 1600's, as a result of the Protestant Reformation and an expansion of learning, new Roman Catholic orders were established to try to meet every humanitarian need. St. Angela Merici founded the Ursulines in Italy. Louise de Marillac and St. Vincent de Paul started the Sisters of Charity in France. St. Jean Baptiste de la Salle founded the Christian Brothers in France as a community of teachers.

Today, there are about $1\frac{1}{3}$ million members of Catholic religious communities throughout the world.

Vatican Council II, which met from 1962 to 1965, urged religious communities to adapt themselves "to the changed conditions of our time." As a result, the communities started a period of adjustment. Encouraged by the Vatican, women in the communities have adapted their clothing and many of their customs to the practical needs of modern life. The practice of poverty in wealthy societies and of obedience in democratic cultures is being modified. However, a balance has not yet been reached between the demands of the present day and the unchangeable principles of Christian perfection.

The Eastern Orthodox Churches regard monasticism as an essential feature of their tradition. Until the 1900's, Eastern Orthodox monks and nuns rarely took part in teaching, preaching, or the ministry. Practically all Eastern Orthodox religions follow the teachings of St Basil. Two characteristics of Eastern Orthodox monasteries are liturgical worship and fasting. Membership in these communities is about 30,000, of whom two-thirds are women.

Of the estimated 550 Orthodox monasteries in Europe and Asia, the most famous is probably the monastic republic of Mount Athos in Greece. There are 20 monasteries on the mountain. Eleven of them follow the *ceno-*

Some leading Christian religious orders

Popular name	Official name	Religion	Founder	Place founded	Date
Benedictines	Order of St. Benedict	Roman Catholic	St. Benedict	Italy	529?
Carmelites	Order of Our Lady of Mount Carmel	Roman Catholic	St. Berthold	Palestine	1100's
Christian Brothers	Brothers of the Christian Schools	Roman Catholic	St. Jean Baptiste de la Salle	France	1680
Cowley Fathers	Society of St. John the Evangelist	Anglican	R. M. Benson	England	1866
Dominicans	Order of Friars Preachers	Roman Catholic	St. Dominic	France	1216
Franciscans	Order of Friars Minor	Roman Catholic	St. Francis of Assisi	Italy	1209
Irish Christian Brothers	Brothers of the Christian Schools of Ireland	Roman Catholic	Edmund Ignatius Rice	Ireland	1802
Jesuits	Society of Jesus	Roman Catholic	St. Ignatius Loyola	France	1534
Monastic Brotherhood	None	Eastern Orthodox	Sts. Pachomius, Basil, Theodore, and Athanasius	Egypt, Asia Minor, and Greece	300's-1000's
Redemptorists	Congregation of the Most Holy Redeemer	Roman Catholic	St. Alphonsus Liguori	Italy	1732
Salesians	Society of St. Francis de Sales	Roman Catholic	St. John Bosco	Italy	1859
Sisters of Charity	Many branches	Roman Catholic	Sts. Vincent de Paul and Louise de Marillac	France	1633
Trappists	Order of Cistercians of the Strict Observance	Roman Catholic	St. Robert of Molesme	France	1098
Wantage Community	Community of St. Mary the Virgin	Anglican	William J. Butler	England	1848

bitic rule, and nine observe the *idiorrhythmic* rule—the approximate ratio for Eastern Orthodox monasticism in general. The cenobitic rule calls for community life under an abbot elected for life. The idiorrhythmic rule provides for monasteries directed by trustees who are elected annually. It gives monks greater freedom in matters of poverty and daily activities.

Protestant churches. Protestant leaders did not encourage religious life under vows during the Reformation of the 1500's. However, a Lutheran Augustinian monastery at Möllenbeck, Germany, existed until 1675. Protestant groups called Pietists, such as the Bohemian Brethren, organized in 1722 in Moravia, formed partially monastic communities that later influenced European and American Protestantism.

By the mid-1800's, certain Protestant denominations had re-established religious communities. A Lutheran community of deaconesses was organized in Germany in 1836. In England, an Anglican group for men was founded in 1842, and one for women was set up in 1845. In 1940, the Taizé community in France was formed under Lutheran and Reformed sponsorship. Today, there are several thousand members in about 100 Protestant religious communities throughout the world. The majority of these Protestant communities are Episcopalian.

Other communities

Among the major world religions, only Hinduism and Buddhism have developed traditions that correspond in some ways to the Christian religious life. The beliefs and practices of Islam and Judaism do not include religious orders or separate communities of monks and nuns.

Hinduism. The closest Hindu equivalent to Christian religious life is the *sannyasi,* the fourth and last stage of a Hindu's life. With advancing age, a Hindu man, alone or with his wife, may retire from active life. He prays, practices severely simple living, and finally reaches a state of spiritual perfection.

Buddhism. Buddha made monasticism an inseparable part of his creed. He planned his religion as a monastic order headed by himself. As Buddhism expanded, members of the laity were included. But they had to affirm their belief in the *Sangha* (monastic order) as strongly as their faith in Buddha and his creed.

According to Buddha, "There are two kinds of gifts, the gift of material things and the gift of *Dharma* (the law). Of these two, the gift of the law is preeminent." An example of the first kind of gift-giving would be monks or nuns living in a community where they own material things in common. An example of the second type would be monks and nuns teaching the methods which must be used in order to attain the state of *nirvana* (perfect happiness).

There were several thousand Buddhist monasteries in China before the Chinese Communists conquered the country in the 1940's. Buddhist monasticism was changed drastically after the Communist take-over of China, Vietnam, and Tibet. The Communists have allowed some monasteries to function in these countries —if the members cultivate an assigned portion of land and raise a quota of crops.

In non-Communist Asia, Buddhist monasticism varies. The greatest differences exist between the Hinayana and Mahayana orders. Hinayana communities have a stricter daily life, and members spend much time in meditation. Most Hinayana communities are in Southeast Asia. Mahayana communities are more active in welfare and education, and are centred in Japan and China.

Related articles in *World Book* include:

Religious orders

Benedict of Nursia, Saint
Benedictines
Capuchins
Carmelites
Carthusians
Cistercians
Dominicans
Franciscans
Jesuits
Knights of Saint John
Knights Templars
Little Sisters of the Poor
Paulists
Sacred Heart of Jesus, Society of the
Sisters of Charity
Sisters of Mercy
Trappists
Ursulines

Other related articles

Abbot
Anthony of Thebes, Saint
Asceticism
Celibacy
Friar
Monasticism
Monk
Nun
Paul of the Cross, Saint

Religious Society of Friends. See Quakers.

Religious tolerance. See Freedom of religion.

REM sleep. See Sleep; Narcolepsy.

Remarque, Erich Maria (1898-1970), a German-American author, wrote realistic, suspenseful novels about the horrors and effects of war. His *All Quiet on the Western Front* (1929) is among the most famous of all war stories. It relates the shattering experiences of a group of German soldiers in World War I.

Remarque followed this success with *The Road Back* (1931) and *Three Comrades* (1937), stories of the confusion in postwar German society and the hardships faced by soldiers who had returned from the trenches. He continued the war theme in *Arch of Triumph* (1946), a novel about a German doctor who fled to Paris to escape the Nazis at the beginning of World War II. *Spark of Life* (1952) is a story of human suffering and courage in a Nazi concentration camp. *The Night in Lisbon* (1964) also describes suffering during World War II.

Remarque was born in Osnabrück, Germany. He fought in World War I, and was wounded several times. In 1933, the Nazis publicly burned his books because of their antigovernment and antimilitarist themes. The Nazis took away his citizenship in 1938. He lived in Switzerland from 1931 to 1939. He moved to the United States in 1939, but often returned to Switzerland. He became a U.S. citizen in 1947.

Rembrandt (1606-1669) was the Netherlands' greatest artist. Rembrandt's output was tremendous. Scholars credit him with about 600 paintings, 300 etchings, and 1,400 drawings. Many other works have been lost. Unlike some other great artists, he wrote almost nothing about his art.

The range of Rembrandt's subjects is extraordinary. His works include landscapes, nudes, portraits, scenes of everyday life, animals and birds, historical and mythological subjects, and works inspired by stories from the Old and New Testaments of the Bible. Throughout his career, Rembrandt also made about 100 known portraits of himself. They form a unique autobiography.

Rembrandt's reputation rests on his power as a storyteller, his warm sympathy, and his ability to show the in-

nermost feelings of the people he portrayed. His use of light and shadow creates an atmosphere that enables us to share his sensitive response to nature and profound understanding of the individual's inner life. Few artists match his genius for showing the human aspect of Biblical characters, yet on the other hand, he was equally capable of suggesting the divine spark which rests in every human being.

Early years. Rembrandt was born in Leiden on July 15, 1606. His full name was Rembrandt Harmenszoon van Rijn. He first studied art with an obscure Leiden painter from about 1621 to 1624. Then he studied with Pieter Lastman in Amsterdam. About 1625, Rembrandt returned to Leiden to paint on his own.

Leiden years: 1625-1631. Most of Rembrandt's early works are small, precisely finished pictures of Biblical and historical subjects. The influence of Lastman can be seen in the lively gestures and expressions of his figures and also in his use of vivid colours and glossy paint. However, Rembrandt rapidly surpassed his teacher's ability to tell a story. He used light and shadow better than anyone else to heighten the drama of his works. Light and shadow became his principal means of pictorial expression.

Rembrandt quickly achieved local success. He began to teach in 1628, and his strong personality continued to attract students and followers throughout his career.

Early Amsterdam years: 1632-1640. About 1632, Rembrandt moved to Amsterdam. He remained there for the rest of his life, except for a few short trips within the Netherlands. In 1634, he married Saskia van Uylenburgh. They had four children, but only one, Titus (1641-1668), survived infancy.

Rembrandt's etching *The Ratkiller* was completed in 1632, the year he established his reputation as a leading artist in the Netherlands. The etching shows Rembrandt's ability to portray common people and scenes from everyday life dramatically.

The British Museum, London

National Gallery of Art, Washington, D.C

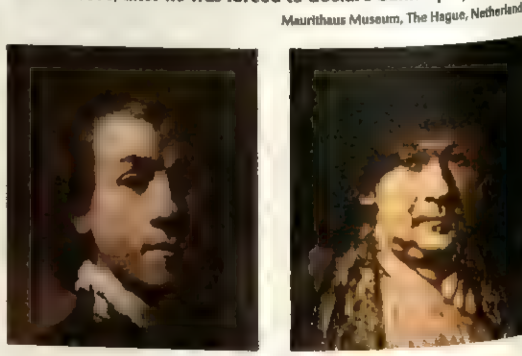
The Descent from the Cross shows how Rembrandt used strong contrasts in light and shadow for dramatic effect. The painting also reveals the artist's genius for portraying people from the Bible in a powerful yet human manner.

In 1632, Rembrandt painted the *Anatomy Lesson of Professor Tulp*. The painting was a group portrait of eight men and immediately established Rembrandt's reputation as the most fashionable portrait painter in Amsterdam. See **World, History of the** (picture: The study of the body). Rembrandt became wealthy, and eagerly collected works of art. In 1639, he bought a large, heavily mortgaged house.

Rembrandt's paintings *Blinding of Samson, Danae,* and *Rape of Ganymede* show the exciting subjects he favoured during these years. They, like most of his other

Rembrandt's self-portraits form a vivid record of his life. The portrait, *left*, was completed in 1629. The portrait, *right*, was finished in 1658, after he was forced to declare bankruptcy.

Maurithaus Museum, The Hague, Netherlands;



works during this period, emphasize dramatic movement, emphatic gestures, sharp contrasts of light and shadow, and striking colour accents.

The last years: 1640-1669. Rembrandt's most famous picture, *The Night Watch,* was painted in 1642. According to a legend, the people who commissioned the portrait were not satisfied with it and refused the painting because Rembrandt would not change it in any way. Because he would not change to please public taste, the tale continues, he soon lost patrons and friends and spent his last years penniless and in total obscurity. However, evidence proves that Rembrandt received a high price for *The Night Watch,* and that he continued to receive important public and private commissions during the last years of his life. These commissions included *Portrait of Jan Six, Conspiracy of Claudius Civilis,* and *The Syndics.*

However, tragedy did strike Rembrandt in 1642 when his beloved wife, Saskia, died. Also, the mature Rembrandt did not enjoy the wide popularity he had as a young painter. Although he still ranked as one of his country's leading artists, he ran short of money. The house he purchased in 1639 was too expensive. Rembrandt also collected works of art on a scale he could not afford. Most important, he began to paint more and more for himself. His late majestic Biblical paintings were not commissioned works. An example of these works, *Jacob Blessing the Sons of Joseph,* is reproduced in the **Painting** article.

During this period, Rembrandt's art gained steadily in spiritual depth and pictorial richness. His wonderful light now seemed to glow from within his works. The shadows became more intense and vibrant. In place of earlier sensational effects, his work shows solemn restraint, calmness, and tenderness. When humanity is represented, the thoughtful rather than active side of human nature is stressed. *Man with a Magnifying Glass,* an example from this period, is reproduced in the **Painting** article. Rembrandt's landscape etchings and drawings during these years have an unmatched sense of space and fresh air.

Rembrandt was forced to declare bankruptcy in 1656. His house and possessions were sold at auction in 1657 and 1658. But when he died on Oct. 4, 1669, he was nevertheless able to leave his surviving relatives a fairly large inheritance.

For other examples of Rembrandt's paintings, see the pictures with the articles **Aristotle** and **Jesus Christ**.

See also **Painting** (The 1600's and 1700's).

Remembrance Day is observed in many Commonwealth countries to honour the memory of all the men and women who died in World Wars I and II and in other conflicts since then. It is held on November 11 in Australia and New Zealand, and on the nearest Sunday to November 11 in the United Kingdom. The date commemorates the armistice that ended World War I, which was signed on Nov. 11, 1918. In the United States, the day is known as Veterans Day and is a public holiday.

Since the 1920's, volunteers have sold artificial poppies on Remembrance Day to raise money to help with the care and rehabilitation of those who suffered in time of war. The flowers are a reminder of the battlefields of Flanders, where small red poppies grew in profusion.

The custom of selling poppies began in Britain on Armistice Day, 1921. The widows of some French ex-servicemen suggested the idea when they called on British commander in chief Earl Haig at the British Legion Headquarters. They brought with them some poppies they had made. They suggested that the flowers could be sold to raise money to help those incapacitated as a result of war.

Poppy Day sales were greatly assisted by the publication of a haunting poem written by John McCrae while serving on the battlefields of Flanders:

> In Flanders fields the poppies grow
> Between the crosses, row on row,
> That mark our place, and in the sky
> The larks still bravely singing, fly
> Scarce heard among the guns below.
> We are the dead. Short days ago
> We lived, felt dawn, saw sunset glow,
> Loved, and were loved, and now we lie
> In Flanders fields.

Remembrance Day is observed with religious services in schools and churches and at war memorials. The services begin with two minutes of silence. Edward George Honey (1885-1922), an Australian journalist and soldier, first suggested the idea of a silent tribute to the

A Remembrance Day service is held in London each year at the Cenotaph in Whitehall. The service commemorates those who died in the two world wars.

persons who died in World War I. In 1919, his suggestion was adopted throughout the British Empire.

Remington, Frederic (1861-1909), was an American artist best known for his action-filled paintings, drawings, and sculptures of cowboys and Indians. His works became famous for capturing the vitality and spirit of the West.

Remington was born in Canton, New York. He loved horses and outdoor life as a child and often sketched Western characters and dramatic battle scenes. He studied art at Yale University from 1878 to 1880. His first published drawing appeared in the campus paper.

In 1881, Remington travelled to Montana on the first of many western trips. He decided in 1885 to become an artist and to devote his art to portraying the rapidly vanishing soldiers, cowboys, Indians, and open lands of the West. He lived in the East, but travelled throughout the West to gather material for his pictures.

Remington's early works were precisely drawn and full of detail. His illustrations for Henry Wadsworth Longfellow's poem *The Song of Hiawatha* (1891) show his technique of this period. Remington later painted with less detail, but he expressed more moods and emotions. He used broader brushstrokes and became more concerned with colour and the effects of light. *Downing the Nigh Leader* (1907) illustrates his late dramatic style. He also gained praise for his quietly romantic night scenes. In his sculptures, Remington made dynamically balanced figures, as in *Bronco Buster* (1905).

Remington illustrated many of his own books, including *Pony Tracks* (1895) and *The Way of an Indian* (1906). Many of his works are in the Remington Art Memorial in Ogdensburg, New York, and the Whitney Gallery of Western Art in Cody, Wyoming.

Bronze sculpture (1895); Frederic Remington Art Museum, New York, U.S.A.

The *Bronco Buster* by Frederic Remington shows the action-filled style he used in his sculptures.

For other examples of Remington's paintings, see the pictures with the following articles: **Cavalry**; and **Pony express**. An example of his sculptures appears in **Sculpture** (American sculpture).

Remora is a fish with a sucker at the top of its head that it uses to attach itself to larger marine animals. Remoras live in warm to tropical seas. They measure about 15 centimetres to 110 centimetres long.

The remora's sucker is a modified *dorsal fin* (back fin) that resembles the sole of a rubber boot. Slatlike structures on the sucker open and close to create powerful suction. Remoras attach themselves to a variety of animals, which are called the *hosts*. These animals include sharks, rays, and other large fish; sea turtles; and whales. Certain types of remoras are found almost exclusively on specific host animals. For example, a species of remora called the *whalesucker* attaches itself only to whales. A remora receives a "free ride" from its host and also may eat scraps of food left by this animal. In turn, the remora rids its host of external parasites. There are some remoras that attach themselves to the hulls of ships or other floating objects.

Scientific classification. The remora belongs to the remora family, Echeneidae. The whalesucker is *Remora australis*.

See also **Fish** (picture: Three remoras).

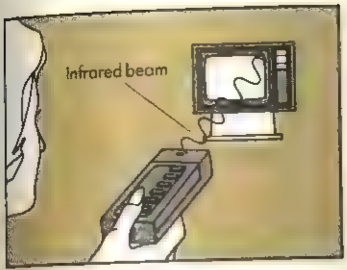
Remote control is the control of a system from a distance. The system may range from a television set to a guided missile or satellite, and the distance may be a few metres or thousands of kilometres. Remote control improves the ease and efficiency of operating various mechanisms. It also helps perform certain tasks that otherwise would be too difficult or dangerous.

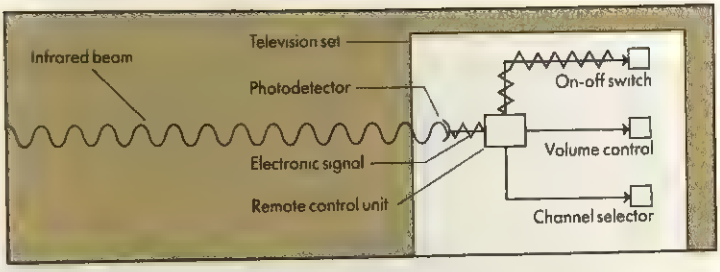
Remote control requires a device called a *command unit*, by which the human operator sends signals that control the system. As the system performs, the operator checks it and may send additional signals to keep it working correctly. In simple remote control systems, the operator can check the performance of the system merely by observing it. Complex systems may include instruments that provide information on performance.

Kinds of remote control can be grouped according to the way the command unit sends signals to the system. Some command units send signals by radio waves. Others use infrared light beams, ultrasonic waves, a device called a laser, electric wires, the human voice, or even mechanical hands.

Radio remote control has many uses. For example, it is used to fly some model aeroplanes. A command unit transmits radio signals to a radio receiver in the plane. The receiver decodes the signals and gives the information to electric motors that control the plane's movements. Model cars and other model toys are operated in the same way. Some radio control systems work with the aid of a computer. These radio control systems help operate automated machines, guided missiles, and many other mechanisms. Controllers on the ground use radio signals to position aerials and operate other equipment on artificial satellites in earth orbit. See **Aeroplane, Model** (Radio control models).

Infrared remote control is used to operate such devices as TV sets and videocassette recorders (VCR's). A device called a *photodetector* receives the beam of infrared rays from the command unit. The photodetector





A remote control television set has a device that sends a beam of infrared rays to the set, *above left.* A photodetector converts the rays to an electronic signal and sends it to a remote control unit, *above right.* This unit controls the on-off switch, volume, and channel selector.

converts the rays into electronic signals, which control the on-off switch, channel selector, and volume.

Sonic remote control is used to operate such devices as telephone answering machines and some TV sets. Microphones in these devices convert ultrasonic or sound waves into electronic signals that go to electric switches. The switches control the operation of the devices.

Human voice control is used to operate light switches and other devices. A microphone in the remote control unit detects a voice or a hand clap and converts the sound into signals that go to the light switch.

Mechanical remote control provides a safe method of handling radioactive materials and other dangerous substances. A technician uses a pair of mechanical hands to work with the hazardous material while viewing it from behind a thick protective screen.

History. The first machines operated by remote control were radio-controlled motorboats. They were developed by the German Navy to ram enemy ships during World War I (1914-1918). Radio-controlled bombs and other remote control weapons were developed during World War II (1939-1945). After the war, United States scientists began to experiment with nonmilitary uses of remote control. Manufacturers introduced automatic garage door openers in the late 1940's, and remote control TV became available in the mid-1950's.

Today, robots operated by remote control are used to perform tasks in dangerous areas. For example, such robots performed much of the cleanup of the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania, U.S.A., after an accident in 1979 released radioactive materials.

See also **Automation; Guided missile.**

Remote sensing is a technique used to gather information about an object without actually touching it. We practise remote sensing with our eyes, ears, and even our skin. These *sensors* obtain information about the size, colour, location, and temperature of objects.

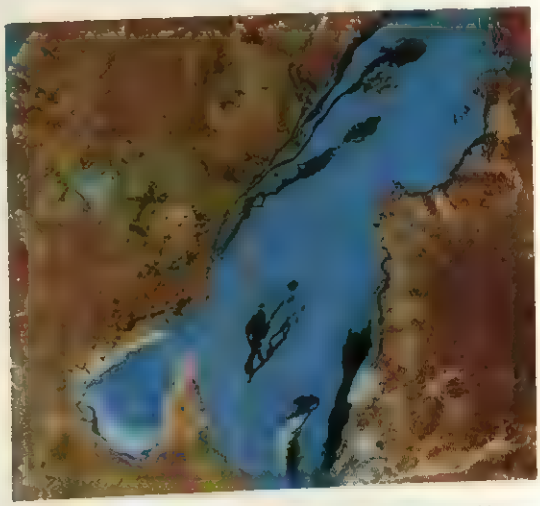
Television also is a form of remote sensing. A TV camera acts as a sensor when it picks up an image and transmits it to a studio. The image is then relayed by cable, broadcasting station, or satellite into viewers' homes. Sensors similar to TV cameras are flown in aircraft and satellites. They relay images of the earth to stations on the ground. Cloud maps used on TV weather forecasts are created from images relayed by satellites orbiting about 35,900 kilometres above the earth.

Some sensors detect invisible forms of energy, especially *infrared rays* (heat rays) that the earth sends out. A computer converts the data into TV pictures or photographs. The colours created by computer are called *false colours* because they do not correspond to the colours we normally see. Radar is a sensor that uses radio waves to make images of moving or fixed objects (see **Radar**). Sonar uses sound waves to map the ocean floor and locate underwater objects (see **Sonar**).

Remote sensing is useful for obtaining information about the earth. Images from satellites are used for estimating crop yields and searching for mineral and petroleum deposits. Remote sensing also helps scientists understand how human activity affects the environment. For example, sensors monitor the health of forests threatened by pollution, map the destruction of tropical rain forests, and measure the warming of the earth's atmosphere known as the *greenhouse effect* (see **Greenhouse effect**).

We can even learn about past environments. Imaging radar has mapped stream channels under the Sahara in southern Egypt, showing that this desert once had a wetter climate.

Remus. See **Romulus and Remus.**



Remote sensing can provide information about the earth's environment. This aerial view from a satellite reveals the extent of a flood in Australia. Water and wet land appear blue or black, vegetation is red, and dry land ranges from brown to white.

Detail of *Family and Court of Ludovico Gonzaga II* (1474), a fresco by Andrea Mantegna, Ducal Palace, Mantua, Italy

The ruling families of the Italian city-states strongly supported the Renaissance. Like the Gonzaga family of Mantua, *above,* they employed many leading artists and scholars at their courts.

Renaissance

Renaissance was a great cultural movement that began in Italy during the early 1300's. It spread to England, France, Germany, the Netherlands, Spain, and other countries in the late 1400's and eventually came to an end about 1600.

The word *Renaissance* comes from the Latin word *renascere* and refers to the act of being reborn. During the Renaissance, many European scholars and artists, especially in Italy, studied the learning and art of ancient Greece and Rome. They wanted to recapture the spirit of the Greek and Roman cultures in their own artistic, literary, and philosophic works. The cultures of ancient Greece and Rome are often called *classical antiquity.* Arabs had taken an interest in Greek and Roman antiquity, especially science, but in Europe such knowledge became lost. The Renaissance thus represented a rebirth of these cultures and is therefore also known as the *revival of antiquity* or the *revival of learning.*

The Renaissance overlapped the end of a period in European history called the Middle Ages, which began in the 400's. The leaders of the Renaissance rejected many of the attitudes and ideas of the Middle Ages. For example, European thinkers in medieval times believed that people's chief responsibility was to pray to God and concentrate on saving their souls. They thought that society was filled with evil temptations. Renaissance thinkers, on the other hand, emphasized people's responsi-

Painted terracotta statue (about 1485) by Andrea del Verrocchio, National Gallery of Art, Washington, D.C.

Lorenzo de' Medici was the political and cultural leader of Florence when the city was the centre of the Italian Renaissance in the 1400's. Lorenzo was called "the Magnificent" because of his achievements as a ruler, supporter of the arts, and author.

bilities and duties to the society in which they lived. They believed that society could civilize people rather than make them wicked.

During the Middle Ages, the most important branch of learning was *theology* (the study of God). However, many Renaissance thinkers paid greater attention to the study of humanity. They examined the great accomplishments of different cultures, particularly those of ancient Greece and Rome.

Medieval artists painted human figures that looked stiff and unrealistic and which often served symbolic religious purposes. But Renaissance artists stressed the beauty of the human body. They tried to capture the dignity and majesty of human beings in lifelike paintings and sculptures.

The changes brought about by the Renaissance happened gradually and did not immediately affect most Europeans. Even at the height of the movement, which occurred during the late 1400's and early 1500's, the new ideas were accepted by relatively few people. But the influence of the Renaissance on future generations was to prove immense in many fields—from art and literature to education, political science, and history. Because of this fact, most scholars have for hundreds of years agreed that the modern era of human history began with the Renaissance.

The Italian Renaissance

Political background. Italy was not a unified country until the 1860's. At the beginning of the Renaissance, it consisted of about 250 separate states, most of which were ruled by a city. Some cities had only 5,000 to 10,000 people. Others were among the largest cities in Europe. For example, Florence, Milan, and Venice had at least 100,000 people each in the early 1300's.

At the dawn of the Renaissance, much of Italy was supposedly controlled by the Holy Roman Empire. However, the emperors lived in Germany and had little power over their Italian lands. The popes ruled central Italy, including the city of Rome, but were unable to extend political control to the rest of Italy. No central authority was therefore established in Italy to unify all the states.

During the mid-1300's and early 1400's, a number of major Italian cities came under the control of one family. For example, the Visconti family governed Milan from the early 1300's until 1447, when the last male member died. Soon after, the Sforza family took control of Milan and governed the city until the late 1400's. Other ruling families in Italy included the Este family in Ferrara, the Gonzaga family in Mantua, and the Montefeltro family in Urbino.

The form of government established by the ruling families of the Italian cities was called the *signoria*, and the chief official was known as the *signore*. All power was concentrated in the signore and his friends and relatives. An elaborate court slowly grew up around each signorial government. At the court, the area's leading artists, intellectuals, and politicians gathered under the sponsorship of the signore.

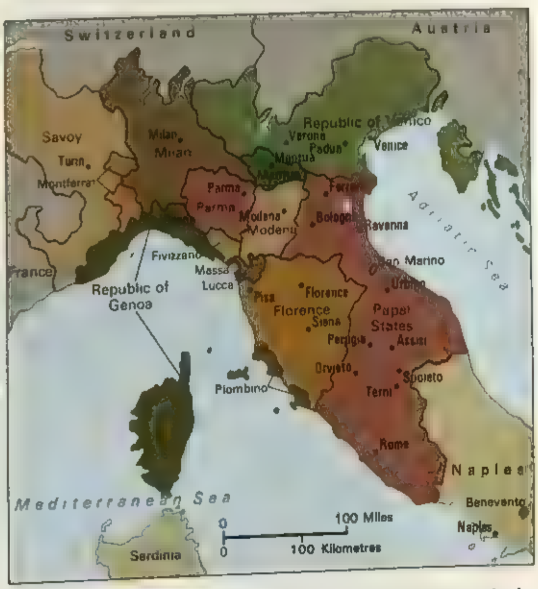
Other Italian cities had a form of government known as *republicanism*. In republican cities, a ruling class controlled the government. Members of the ruling class considered themselves superior to the other residents of the city. The most important examples of republican government were in Florence and Venice.

In the republican government of Florence, about 800 of the city's wealthiest families made up the ruling class. The members of these Florentine families intermarried and lived in large, beautiful palaces built by Renaissance architects. They paid for the construction of great religious and civic buildings and impressive monuments throughout Florence. They also supported artists and intellectuals. In addition, the ruling class encouraged the study of ancient Greek and Roman authors in the desire to have their society resemble the cultures of classical antiquity.

By the 1430's, the Medici family dominated the ruling class of Florence. The family controlled the largest bank in Europe and was headed by a series of talented and ambitious men. Under Medici domination, the government of Florence resembled a signorial government.

About 180 families controlled the republican government of Venice. All government leaders came from these families. A law passed in 1297 restricted membership in the Great Council, the principal governing body, to descendants of families that had already sat in the council. Like Florence, Venice became a leading centre of Renaissance art under the support of the ruling class.

Humanism was the most significant intellectual movement of the Renaissance. It blended concern for the history and actions of human beings with religious concerns. The humanists were scholars and artists who studied subjects that they believed would help them better understand the problems of humanity. These subjects included literature and philosophy. The humanists shared the view that the civilizations of ancient Greece and Rome had excelled in such subjects and thus could serve as models. They believed that people should un-



Renaissance Italy consisted of about 250 states, most of which were ruled by a city. The Renaissance began during the 1300's in the *city-states* of northern Italy. Early centres of the Renaissance included the cities of Florence, Milan, and Venice.

derstand and appreciate classical antiquity to learn how to conduct their lives.

To understand the customs, laws, and ideas of ancient Greece and Rome, the humanists had first to master the languages of classical antiquity. The Greeks had used a language foreign to Italians, and the Romans had used a form of Latin far different from that used in the 1300's and 1400's. To learn ancient Greek and Latin, the humanists studied *philology* (the science of the meaning and history of words). Philology became one of the two principal concerns of the humanists. The other was history, which the humanists saw as the study of great actions taken by courageous, noble, or wise men of classical antiquity.

The interest of the humanists in ancient Greece and Rome led them to search for manuscripts, statues, coins, and other surviving examples of classical civilization. For example, they combed monastery libraries throughout Europe, locating on dusty shelves long neglected manuscripts by classical authors. The humanists carefully studied these manuscripts, prepared critical editions of them, and often translated them.

Petrarch and ***Giovanni Boccaccio*** were the first Renaissance humanists. During the mid-1300's, the two friends recovered many important but long ignored ancient manuscripts. Petrarch discovered the most influential of these works. It was *Letters to Atticus*, a collection of letters on Roman political life by the statesman and orator Marcus Tullius Cicero.

As Petrarch and Boccaccio studied the rediscovered classical writings, they tried to imitate the styles of the ancient authors. They urged that people express themselves accurately and elegantly, characteristics they saw in classical literary style. Petrarch said, "The style is the man." He meant that careless expression reflected careless thought.

Petrarch became known for his poetry, and Boccaccio for his collection of stories called the *Decameron* (about 1349-1353). In their works, they tried to describe human feelings and situations that people could easily understand. Petrarch and Boccaccio insisted that the duty of intellectuals was to concentrate on human problems, which they believed were more important than an understanding of the mysteries of nature or of God's will. They thought that people could learn how to deal with their problems by studying the lives of individuals of the past.

The ideal courtier. Some Italian humanists spent most of their time in signorial courts. During the late 1400's, these humanists began to develop ideas about the proper conduct of *courtiers*—the noblemen and noblewomen who lived in a royal court. About 1518, an author and diplomat named Baldassare Castiglione completed *The Book of the Courtier*. Castiglione based the work on his experiences at the court of Urbino. It was translated into several European languages and influenced the conduct of courtiers throughout Europe. *The Courtier* also strongly influenced educational theory in England during the Renaissance.

Castiglione wrote that the ideal male courtier is re-

Detail of *The Madonna Enthroned with Angels* (about 1285), an oil painting on wood panel by Cimabue; Uffizi Palace, Florence, Italy

Detail of *The Small Cowper Madonna* (1505), an oil painting on wood panel by Raphael; National Gallery of Art, Washington, D.C.

Medieval and Renaissance art differed in the portrayal of the human figure. The medieval painting at the left has unlifelike figures that represent religious ideas, not flesh-and-blood people. The Renaissance painting at the right shows realistic figures in a natural setting.

fined in writing and speaking and skilled in the arts, sports, and the use of weapons. He willingly devotes himself to his signore, always seeking to please him. The courtier is polite and attentive to women. Whatever he does is achieved with an easy, natural style, which reflects his command of every situation. An ideal court woman knows literature and art and how to entertain the court. She exhibits the highest moral character and acts in a feminine manner.

The fine arts. During the Middle Ages, painters and sculptors tried to give their works a spiritual quality. They wanted viewers to concentrate on the deep religious meaning of their paintings and sculptures. They were not concerned with making their subjects appear natural or lifelike. But Renaissance painters and sculptors, like Renaissance writers, wanted to portray people

Bronze statue (1430's); Bargello, Florence, Italy

Donatello's *David* was the first large free-standing nude since classical antiquity. The sculptor's emphasis on the subject's physical beauty greatly influenced other Renaissance artists.

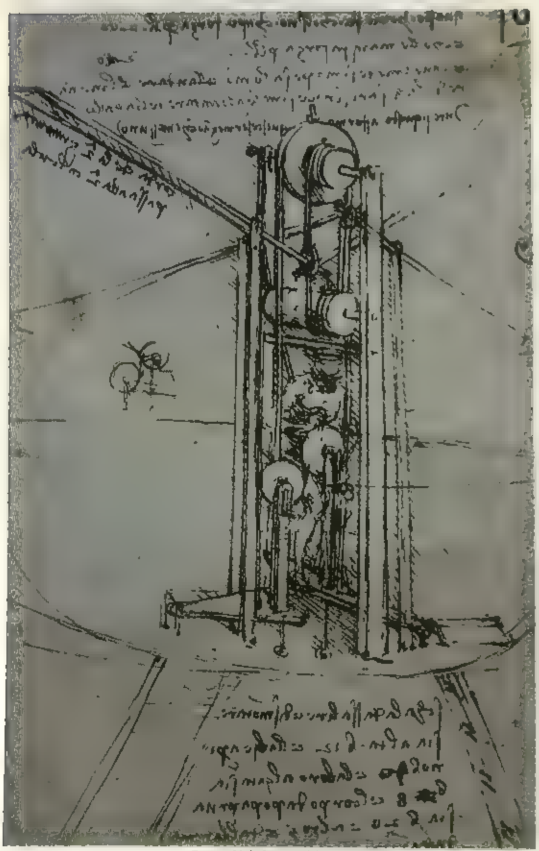
The Pazzi Chapel in Florence, Italy, was one of the first buildings designed in the Renaissance style. The chapel was begun in 1429 and completed in 1461. The architect, Filippo Brunelleschi, incorporated arches, columns, and other elements of classical architecture into his design. Both the exterior, *above,* and the interior, *right,* have been praised for the beauty and harmony of their proportions.

and nature realistically. Architects of the Middle Ages designed huge cathedrals to emphasize the majesty and grandeur of God. Renaissance architects designed buildings on a smaller scale to help make people aware of their own powers and dignity.

Arts of the 1300's and early 1400's. During the early 1300's, the Florentine painter Giotto became the first artist to portray nature realistically. He produced magnificent *frescoes* (paintings on damp plaster) for churches in Florence, Padua, and Assisi. Giotto attempted to create lifelike figures showing real emotions. He portrayed many of his figures in realistic settings.

A remarkable group of Florentine architects, painters, and sculptors worked during the early 1400's. They included the architect Filippo Brunelleschi, the painter Masaccio, and the sculptor Donatello.

Brunelleschi was the first Renaissance architect to revive the ancient Roman style of architecture. He incorporated arches, columns, and other elements of classical architecture into his designs. One of his best-known buildings is the beautifully and harmoniously proportioned Pazzi Chapel in Florence. The chapel, begun in 1429, was one of the first buildings designed in the new Renaissance style. Brunelleschi also was the first Renaissance artist to use *linear perspective*, a mathematical system in which painters could show space and depth on a flat surface.



Pen-and-ink drawing (about 1488); Bibliothèque Nationale, Paris

The drawings of Leonardo da Vinci reveal the inquiring mind of perhaps the greatest intellect of the Renaissance. Leonardo was fascinated by the possibility of human flight. He designed a flying machine that used revolving paddles, *above*.

Masaccio's finest work was a series of frescoes he painted about 1427 in the Brancacci Chapel of the Church of Santa Maria del Carmine in Florence. The frescoes realistically show Biblical scenes of emotional intensity. Masaccio created the illusion of space and depth in these paintings by using Brunelleschi's mathematical calculations.

In his sculptures, Donatello tried to portray the dignity of the human body in realistic and often dramatic detail. His masterpieces include three statues of the Biblical hero David. In a version completed in the 1430's, Donatello portrayed David as a graceful, nude youth, moments after he slew the giant Goliath. The work, about 1.5 metres tall, was the first large free-standing nude created in Western art since classical antiquity.

Arts of the late 1400's and early 1500's were dominated by three men. They were Michelangelo, Raphael, and Leonardo da Vinci.

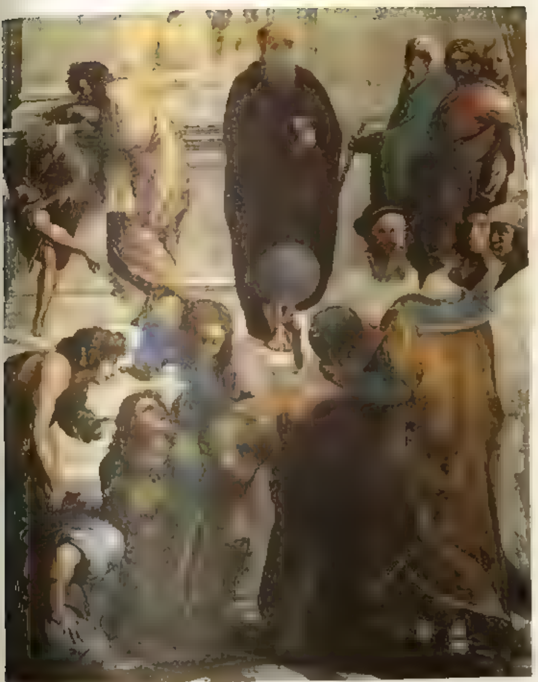
Michelangelo excelled as a painter, architect, and poet. In addition, he has been called the greatest sculptor in history. Michelangelo was a master of portraying the human figure. For example, his famous statue of the Israelite leader Moses (1516) gives an overwhelming impression of physical strength and spiritual power. These qualities also appear in the frescoes of Biblical and classical subjects that Michelangelo painted on the ceiling of the Sistine Chapel in the Vatican. The frescoes were painted from 1508 to 1512 and rank among the greatest achievements of Renaissance art.

Raphael's paintings are softer in outline and more poetic than those of Michelangelo. Raphael was skilled in creating perspective and in the delicate use of colour. He painted a number of beautiful pictures of the Madonna (Virgin Mary) and many outstanding portraits. One of his greatest works is the fresco *School of Athens* (1511). The painting was influenced by classical Greek and Roman models. It portrays the great philosophers and scientists of ancient Greece in a setting of classical arches. Raphael was thus making a connection between the culture of classical antiquity and the Italian culture of his time.

Leonardo da Vinci painted two of the most famous works of Renaissance art, the fresco *The Last Supper* (about 1497) and the portrait *Mona Lisa* (about 1503). Leonardo had one of the most searching minds in all history. He wanted to know the workings of everything he saw in nature. In more than 4,000 pages of notebooks, he drew detailed diagrams and wrote down observations. Leonardo made careful drawings of human skeletons and muscles, trying to discover how the body worked. Because of his inquiring mind, Leonardo has become a symbol of the Renaissance spirit of learning and intellectual curiosity.

The Renaissance outside Italy

During the late 1400's, the Renaissance spread from Italy to such countries as France, Germany, England, and Spain. It was introduced into those countries by visitors to Italy, who included merchants, bankers, diplomats, and especially young scholars. The scholars acquired from the Italians the basic tools of humanistic study—history and philology.



Detail of a fresco (1510-1511); The Vatican, Rome

Raphael's *School of Athens* portrays an imaginary gathering of ancient Greek philosophers and scientists, including the mathematician Euclid, *bending forward, foreground.* The painting shows the Renaissance respect for classical culture.

A series of invasions of Italy also played a major role in the spread of the Renaissance to other parts of Europe. From 1494 to the early 1500's, Italy was repeatedly invaded by armies from France, Germany, and Spain. The invaders were dazzled by the beauty of Italian art and architecture and returned home deeply influenced by Italian culture.

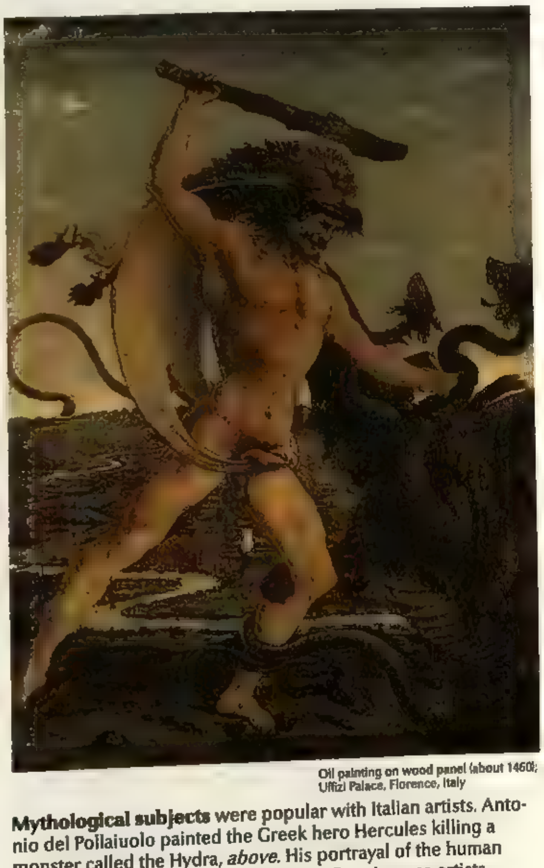
In Italy, evidence of classical antiquity, especially Roman antiquity, could be seen almost everywhere. Ruins of Roman monuments and buildings stood in every Italian city. This link between the present and the classical past was much weaker elsewhere in Europe. In ancient times, Roman culture had been forced upon northern and western Europeans by conquering Roman armies. But that culture quickly disappeared after the Roman Empire in the West fell in the A.D. 400's.

The relative scarcity of classical art affected the development of European art outside Italy during the 1400's. Painters had few examples of classical antiquity to imitate, and so they tended to be more influenced by the northern Gothic style of the late Middle Ages. The first great achievements in Renaissance painting outside Italy appeared in the works of artists living in Flanders. Most of the Flanders region lies in what are now Belgium and France. Flemish painting was known for its precise details. The human figures were realistic but lacked the sculptural quality that was characteristic of Italian painting.

Political background. During the Renaissance, the political structure of northern and western Europe differed greatly from that of Italy. By the late 1400's, England, France, and Spain were being united into nations under monarchies. These monarchies provided political and cultural leadership for their countries. Germany, like Italy, was divided into many largely independent states. But Germany was the heart of the Holy Roman Empire, which tended to unify the various German states to some extent.

The great royal courts supported the Renaissance in northern and western Europe much as the cities did in Italy. For example, the French king Francis I, who ruled from 1515 to 1547, tried to surround himself with the finest representatives of the Italian Renaissance. The king brought Leonardo da Vinci and many other Italian artists and scholars to France. In England, the House of Tudor became the most important patron of the Renaissance. The Tudors ruled from 1485 to 1603. Henry VII, the first Tudor monarch, invited numerous Italian humanists to England. These men encouraged English scholars to study the literature and philosophy of ancient Greece and Rome.

Christian humanism. Renaissance scholars in northern and western Europe were not as interested as the Italians in studying classical literature. Instead, they sought to apply humanistic methods to the study of Christianity. These scholars were especially concerned with identifying and carefully editing the texts on which Christianity was based. These texts included the Bible, the letters of Saint Paul, and the works of such great early church leaders as Saint Ambrose, Saint Jerome,



Oil painting on wood panel (about 1460); Uffizi Palace, Florence, Italy

Mythological subjects were popular with Italian artists. Antonio del Pollaiuolo painted the Greek hero Hercules killing a monster called the Hydra, *above.* His portrayal of the human body in vigorous action inspired other Renaissance artists.

Detail of *The Madonna and Child with Chancellor Rolin* (about 1436), an oil painting on wood panel; the Louvre, Paris

A northern Renaissance painting by the Flemish artist Jan van Eyck emphasizes lighting, perspective, and details. Van Eyck was one of the first major Renaissance artists outside Italy.

and Saint Augustine. The scholars became known as *Christian humanists* to distinguish them from those humanists who were chiefly involved with the study of classical antiquity.

Desiderius Erasmus and Saint Thomas More were the leading Christian humanists. They were close friends who courageously refused to abandon their ideals.

Erasmus was born in the Netherlands. He was educated in Paris and travelled throughout Germany, England, and Italy. He was an excellent scholar, with a thorough knowledge of Latin and Greek.

Erasmus refused to take sides in any political or religious controversy. In particular, he would not support either side during the Reformation, the religious movement of the 1500's that gave birth to Protestantism. Both Roman Catholics and Protestants sought Erasmus' support. He stubbornly kept his independence and was called a coward by both sides. However, Erasmus did attack abuses he saw in the church in a famous witty work called *The Praise of Folly* (1511). In this book, Erasmus criticized the moral quality of church leaders. Erasmus also accused them of overemphasizing procedures and ceremonies while neglecting the spiritual values of Christianity.

Saint Thomas More was born in England and devoted his life to serving his country. He gained the confidence of King Henry VIII and carried out a number of important missions for him. In 1529, the king appointed More lord chancellor, making him England's highest judicial official.

Throughout his career, More dedicated himself to the principles that had inspired Erasmus. Like Erasmus, he believed it was important to eliminate the abuses, inequalities, and evils that were accepted as normal in his day. More's best-known work is *Utopia* (1516). In this book, More described a society in which the divisions between the rich and the poor and the powerful and the weak were replaced by a common concern for the health and happiness of everyone.

More's strong principles finally cost him his life. He objected to Henry VIII's decision to divorce the queen, Catherine of Aragon, and remarry. More then refused to take an oath acknowledging the king's authority over that of the pope. In 1535, More was beheaded for treason.

The heritage of the Renaissance

The Renaissance left an intellectual and artistic heritage that still remains important. Since the Renaissance, scholars have used Renaissance methods of humanistic inquiry, even when they did not share the ideas and spirit of the Renaissance humanists. In literature, writers have tried for centuries to imitate and improve upon the works of such Renaissance authors as Petrarch and Boccaccio.

The influence of Renaissance painters, sculptors, and architects has been particularly strong. The artists of Florence and Rome set enduring standards for painting in the Western world. For hundreds of years, painters have travelled to Florence to admire the frescoes of Giotto and Masaccio. They have visited Rome to study the paintings of Raphael and Michelangelo. The works of Donatello and Michelangelo have inspired sculptors for generations. The beautifully scaled buildings of Brunelleschi and other Renaissance architects still serve as models for architects.

Since the Renaissance, people have also been inspired by the intellectual daring of such men as Petrarch and Erasmus. Leaders of the Renaissance seemed to be

Detail of an oil painting on wood panel (about 1523) by Hans Holbein the Younger; the Louvre, Paris

Desiderius Erasmus, a Dutch priest and scholar, became a leading Christian humanist during the Renaissance. He often attacked religious superstition and abuses he saw in the church.

breaking out of intellectual boundaries and entering unknown territories. It is perhaps no coincidence that some of the greatest explorers of the late 1400's and early 1500's were Italians exposed to the influence of the Renaissance. Christopher Columbus was a Genoese navigator who, for his New World voyages, consulted the same scientist who taught mathematics to the architect Brunelleschi. Columbus and fellow Italians John Cabot, Giovanni da Verrazano, and Amerigo Vespucci in many ways epitomized the spirit of the Renaissance as they ventured to discover new horizons.

Related articles in *World Book* include:

Architects

Alberti, Leon Battista	Jones, Inigo
Bramante, Donato	Palladio, Andrea
Brunelleschi, Filippo	

Painters

Bellini, Gentile	Holbein, Hans, the Younger
Bellini, Giovanni	Leonardo da Vinci
Bellini, Jacopo	Lippi, Filippino
Botticelli, Sandro	Lippi, Filippo
Bruegel, Pieter, the Elder	Mantegna, Andrea
Campin, Robert	Masaccio
Caravaggio, Michelangelo Merisi da	Michelangelo
Dürer, Albrecht	Piero della Francesca
Fra Angelico	Pollaiuolo, Antonio del
Ghirlandajo, Domenico	Raphael
Giorgione	Tintoretto
Giotto	Titian
Greco, El	Uccello, Paolo
Grünewald, Matthias	Van der Weyden, Rogier
Holbein, Hans, the Elder	Van Eyck, Jan
	Veronese, Paolo

Political leaders

Borgia	Machiavelli, Niccolò
Francis I (of France)	Medici

Sculptors

Cellini, Benvenuto	Michelangelo
Della Robbia	Pisano, Giovanni
Donatello	Pisano, Nicola
Ghiberti, Lorenzo	Verrocchio, Andrea del

Writers

Ariosto, Ludovico	Petrarch
Boccaccio, Giovanni	Rabelais, François
Bruno, Giordano	Ronsard, Pierre de
Castiglione, Baldassare	Shakespeare, William
Cervantes, Miguel de	Spenser, Edmund
Erasmus, Desiderius	Surrey, Earl of
Marlowe, Christopher	Tasso, Torquato
Marot, Clement	Vega, Lope de
Montaigne, Michel de	Wyatt, Sir Thomas
More, Saint Thomas	

Other related articles

See the section on the *Renaissance* in the various articles on national literatures, such as **Italian literature** (The Renaissance). See also the following articles:

Architecture	Furniture
Classical music	Humanism
Clothing	Italy (History)
Dancing	Literature
Democracy (Development)	Mural
Drama	Painting
Education (The Renaissance)	Philosophy
Exploration (The great age of European discovery)	Poetry
Florence	Reformation
Fresco	Science
	Sculpture

Outline

I. The Italian Renaissance
- A. Political background
- B. Humanism
- C. The fine arts

II. The Renaissance outside Italy
- A. Political background
- B. Christian humanism
- C. Desiderius Erasmus and Saint Thomas More

III. The heritage of the Renaissance

Questions

What was the most significant intellectual movement of the Renaissance?
What is meant by *classical antiquity*?
How did the Renaissance spread from Italy?
What are some lasting achievements of the Renaissance?
How did many attitudes and ideas of the Renaissance differ from those of the Middle Ages?
What three men dominated Italian arts during the late 1400's and early 1500's?
How did the signorial and republican governments of the Italian cities promote the Renaissance?
Why was *philology* studied during the Renaissance?
What was *The Book of the Courtier* and why was it important?
Who were the *Christian humanists*?

Rene, Roy (1892-1954), was a leading Australian comedian from 1914 until his death. Rene was born in Adelaide, South Australia, and named Harry van der Sluys. He began his career as a boy soprano, calling himself Harry Sluice. He adopted the name Roy Rene in 1914, when he began a long career at the Tivoli Theatres in Melbourne and Sydney in an act known as *Stiffy and Mo*. Rene later performed with Hal Lashwood and Eddie Finn in the radio series *Mo McCackie Mansions*.

Renfrew (pop. 193,622) was a local government district in Strathclyde Region, Scotland that included the manufacturing towns of Barrhead, Johnstone, Paisley, and Renfrew. With effect from 1996, Renfrew was replaced by Renfrewshire Council.

In the rural areas of the district, arable farming is the main activity. Engineering and the manufacture of textiles are the main industries. Paisley is a leading world producer of cotton thread. Other industries include food processing, and the tanning of leather.

Renin. See **Hypertension**.

Rennie, John (1761-1821), a Scottish engineer and architect, constructed canals, docks, and bridges. His canals included some large aqueducts and tiers of locks. He designed the old London, Southwark, and Waterloo bridges. Rennie also designed docks in the Port of London and at Dublin, Greenock, Hull, and Liverpool. He built the breakwater across Plymouth Sound. Rennie was born at Phantassie, Lothian Region, and studied at Edinburgh University.

Reno (pop. 133,850; met. area pop. 254,667) is a major tourist centre and the second largest city in Nevada, United States. Only Las Vegas has more people. Reno lies on the Truckee River in western Nevada at the foot of the Sierra Nevada.

Reno has many gambling casinos and nightclubs. The MGM Grand Hotel in Reno is the largest hotel and gambling casino complex in the world.

Paiute and Washo Indians lived in what is now the Reno area before white settlers arrived. Reno was founded in 1868 as a station on the Central Pacific Railroad. The city grew rapidly after Nevada legalized gambling in 1931.

Reno, Janet (1938-), became the first woman to serve as attorney general of the United States. She was appointed by President Bill Clinton in 1993. Before her appointment, Reno had served for 15 years as state attorney for Florida's Dade County, which includes Miami and its suburbs.

Reno was born in Miami. She graduated from Cornell University in 1960 with a bachelor's degree in chemistry. She received a law degree from Harvard University in 1963.

Renoir, Jean (1894-1979), was a French film director. Many of his films expose human faults and ridicule social attitudes. However, they also show compassion for people and their failings. Renoir directed 36 films, including two of the most acclaimed films ever made. One of them, *The Grand Illusion* (1937), attacks the futility of war. The other, *The Rules of the Game* (1939), satirizes relationships among upper-class people at a weekend house party.

Renoir was born in Paris. His father was the French painter Pierre Auguste Renoir. After World War II began in 1939, Jean Renoir fled France. He settled in the United States in 1941. Renoir made several films in the United States, including *Swamp Water* (1941) and *The Southerner* (1945). He became a U.S. citizen in 1944.

Renoir, Pierre Auguste (1841-1919), a French impressionist painter, is famous for his pictures of young girls and children, and intimate portraits of French middle-class life. He loved to show lively groups in sensuous surroundings, and often used his friends as models. His *Oarsmen at Chatou* and *The Children's Afternoon at Wargemont* appear in the **Painting** article. He frequently painted his wife and children.

In the 1870's, Renoir and Claude Monet together developed the broken colour technique of the impressionists. Instead of mixing paints completely, they left small dabs of colour in a sketchy manner. But Renoir was more interested in rich colour effects and a sense of volume than Monet. Renoir also preferred figure painting to landscapes.

During the 1870's, Renoir painted a large number of portraits on commission. Perhaps Renoir's most famous portrait is *Mme. Charpentier and Her Children.* While many impressionists brought Japanese qualities into their paintings, Renoir revived the rococo style of such painters as François Boucher and Jean Honoré Fragonard.

Renoir travelled to Italy in 1880, and his study of Renaissance painters there led him to a new appreciation of the importance of line. He returned to France, where he gave up his broad, colouristic manner and spent several years concentrating on drawing. He painted a famous series, *The Bathers,* during this time.

The happy quality of Renoir's later work does not show the agony he suffered from arthritis, which finally crippled his hands. He had brushes tied to his hands and developed a final style of painting in broad brush strokes and vivid colours.

Renoir was born in Limoges, France. He was apprenticed to learn porcelain painting after he showed an early talent for drawing. He painted window blinds and fans in Paris. He studied at Charles Gleyre's studio, where he met Monet and other young painters who were to form the impressionist group. He was influenced also by Edouard Manet and the colour methods of Eugène Delacroix.

See also **Delacroix, Eugène; Manet, Edouard; Monet, Claude; Impressionism.**

Rent commonly refers to a payment for the use of something, such as a house. But it is also possible to rent such things as a car or a fancy dress costume. The word *rent,* in economics, has a technical meaning and usually applies only to land. This article deals with such *economic rent.*

Oil painting on canvas (1881); the Phillips Collection, Washington, D.C.

Pierre Auguste Renoir, a master of impressionist painting, became famous for his luminous colours and cheerful scenes of everyday life. In such works as *The Luncheon of the Boating Party, left,* he portrayed a carefree group of people at an informal moment. The woman holding the dog is Renoir's wife.

Economic rent refers to the difference between the yield from a good piece of land and the yield that could have been obtained with the same expenditure from the same amount of *marginal land.* Marginal land is a piece of land that yields just enough to pay all the costs of cultivating it and is barely worth cultivating.

If all land had the same quality, and if enough of it existed, there would be no such thing as rent. People would not pay for the use of land if they could have equally good land for nothing. However, since there is not enough good land for everyone, the people who own the better land charge a rental for its use.

Reorganized Church of Jesus Christ of Latter Day Saints. See Latter Day Saints, Reorganized Church of Jesus Christ of.

Repeal means wiping out a law already on the books. A legislative body has the power not only to pass new laws, but also to do away with laws that have been passed earlier. Sometimes, the legislature may pass an act which directly states that an earlier law is repealed. Such an act is known as an *express repeal.* Sometimes, a new law may simply make it quite clear that an older one no longer applies. In this case, the repeal is known as a *repeal by implication.* A new law will sometimes conflict only with a certain portion of an earlier one. The new law is understood to repeal by implication those parts of the earlier law that are inconsistent with it.

Reporter. See Journalism; **Newspaper** (Gathering the news); **War correspondent.**

Representative government. See **Democracy; Republic.**

Representatives, House of. See **House of Representatives.**

Repression. See Psychology (Psychoanalysis); **Psychotherapy** (Analytic psychotherapy).

Reprieve is the temporary suspension of a sentence passed on a criminal. Reprieves are sometimes granted to permit consideration of new evidence, or a further investigation of the case. The chief executive of a state or country usually grants reprieves. A reprieve is not a pardon (see **Pardon**). It makes no change in the sentence, but merely changes the date when the sentence goes into effect. A delay or reprieve granted to a prisoner by the court which passed the sentence is often called a *stay of execution.*

Reproduction is the process by which living things create more of their own kind. All types of living creatures reproduce, from the tiniest bacteria to the largest plants and animals. Without reproduction, all forms of life would die out.

Organisms can produce offspring like themselves because they possess *genes.* Genes are tiny segments of DNA (deoxyribonucleic acid), the substance that determines an organism's essential traits. Genes are contained in each cell of an organism and are transferred to the organism's offspring during reproduction.

There are two general types of reproduction—*sexual* and *asexual.* In sexual reproduction, a new organism is formed by the joining of a *gamete* (sex cell) from one organism with a gamete from another organism. Human beings and almost all other animals reproduce sexually. In asexual reproduction, a new organism develops from parts of, or parts produced by, one organism. Living things that reproduce asexually include bacteria and other simple organisms. Many organisms can reproduce both sexually and asexually. They include most plants and fungi and certain simple animals, such as sponges.

Reproduction is the process by which all living things create offspring like themselves. In this photograph, a mother sheep cleans her newborn, moments after giving birth.

Scientists believe that the first living things lived in the sea and reproduced asexually. Sexual reproduction also *evolved* (developed gradually) in the sea. After organisms began to live on land, they evolved increasingly complex methods of sexual reproduction.

This article describes reproduction in living things other than human beings. For a discussion of human reproduction, see **Reproduction, Human.**

How genes are transferred

During reproduction, an organism transmits a copy of its genes to its offspring. Genes are contained in threadlike structures called *chromosomes.* Bacteria, which are one-celled organisms, have only one chromosome, consisting of a single strand of DNA. In more complex organisms, each body cell contains two copies of each chromosome, and the two copies are arranged in pairs. Cells with paired chromosomes are called *diploid cells.* Cells that contain only one copy of each chromosome are called *haploid cells.*

Through sexual reproduction, the offspring inherits its genes from two parents. The genes are transmitted by the two gametes that form the new individual. Sexual reproduction involves a cycle of two processes, *meiosis* and *fertilization.* In meiosis, diploid cells produce gametes, which are haploid cells. The male gamete is called a *sperm,* and the female gamete is called an *egg.* Fertilization is the union of these gametes. It produces a diploid cell, the fertilized egg. The fertilized egg develops into the new organism. Because it receives genes from each parent, the offspring has a unique genetic makeup and traits that differ from those of either parent.

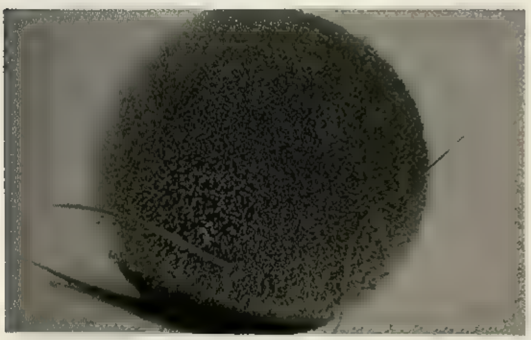
Through asexual reproduction. Although many diploid organisms reproduce sexually, others reproduce asexually. For example, sponges are diploid ani-

mals that can reproduce by a process called *budding.* In this process, a small portion of the sponge breaks off and gives rise to a new individual. There is no meiosis and no fertilization. A similar process, called *vegetative propagation,* occurs in many plants (see **Plant** [Vegetative propagation]).

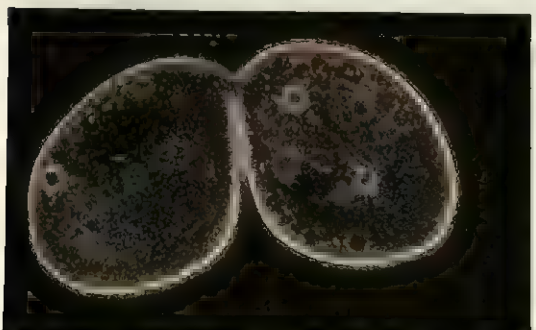
Another form of asexual reproduction occurs in bacteria and other one-celled organisms. Such organisms simply divide when they grow to a certain size. This process is called *binary fission.* Before dividing, the organism makes a copy of its chromosomes, which contain the genes. The cell splits between the two copies so that each of the resulting cells gets one of the copies. Thus, in asexual reproduction, every cell of the new organism has the same genes as the parent, and the offspring and the parent are identical.

How reproduction has evolved

Most scientists believe that life arose on earth about 3½ billion years ago. The first living things probably were microscopic, one-celled organisms that lived in the sea and reproduced asexually. Sexual reproduction also evolved in the sea. Sea animals reproduce sexually by means of *external fertilization.* In this process, the female releases eggs into the water. Fertilization occurs after a male releases sperm into the water and the sperm unite with the eggs.



In sexual reproduction, a new organism forms from the union of a sperm from the male parent and an egg from the female parent. In this photograph, the whiplike sperm of a hamster penetrates a round hamster egg.



In asexual reproduction, a new organism develops from a single parent organism. This photograph shows a paramecium splitting into two individuals, a process called *binary fission.*

About 400 million years ago, some organisms left the sea to inhabit land. The new, dry environment presented problems for existing methods of reproduction. Organisms that reproduced sexually could not simply release their gametes near one another on land since the gametes would dry up and die. Thus, organisms evolved new reproduction methods suitable to land conditions.

Plants evolved seeds, watertight structures that enclose the plant's *embryo* (fertilized egg). The seed keeps the embryo from drying out until enough water is available for it to grow.

Fungi developed a form of reproductive cell called the *spore,* which only begins to grow when water is available.

Amphibians, such as frogs and toads, fertilize their eggs externally in a puddle or pond. The fertilized egg of an amphibian does not contain enough nutrients for the offspring to develop completely by the time the egg hatches. As a result, an amphibian goes through a *larval stage* after it hatches and before it becomes an adult. During the larval stage, the animal gathers and eats the food it needs to reach full maturity.

Insects developed eggs with shells that retain water. The female can lay the eggs on twigs and other places exposed to air without their loss of moisture. In most insects, the eggs are fertilized as they leave the female's body by sperm stored in her abdomen.

Reptiles and birds. Reptiles evolved *internal fertilization,* a process in which the male releases sperm into an opening in the female's body. The egg is fertilized within the female's body, where it is completely protected from drying out. Most scientists believe that birds evolved from reptiles. The eggs of reptiles and birds contain a large amount of nutrients and are within a watertight shell. The offspring develops within the egg, eventually using up all the nutrients and developing into a miniature adult before it hatches.

Mammals. Reproduction in mammals involves internal fertilization. Like reptiles, the earliest mammals laid eggs. Only two such mammals, the echidna and the platypus, survive today. In all other mammals, the young are born alive.

Certain mammals, called *marsupials,* give birth to extremely underdeveloped young. The young continue their development in a pouch on the mother's body, where they feed on the mother's milk. Marsupials include kangaroos, opossums, and koalas.

The great majority of mammals, however, give birth to well-developed offspring. While in the body of the mother, the young of these mammals receive nourishment from the mother's blood through a specialized organ called the *placenta* (see **Placenta**). Such mammals are called *placentals.*

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Bacteria (How bacteria reproduce)
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Insect (Reproduction)
Mammal (How mammals reproduce)
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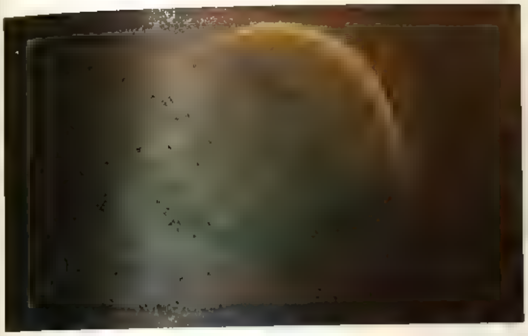
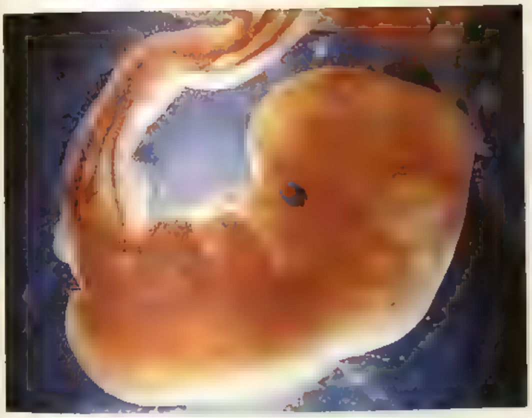




Human reproduction begins when a sperm from the father unites with and fertilizes an egg from the mother. The egg divides rapidly, *top left,* and soon becomes an embryo, *above left,* that develops and grows within the mother's body. After about nine months, a baby is born, *right.*

Human reproduction

Reproduction, Human, is the process by which human beings create more of their own kind. Human beings reproduce sexually. That is, a new individual human being develops from the joining together of two sex cells, one from the female parent and one from the male parent. The union of these cells is called *fertilization.*

Biologists refer to sex cells as *gametes.* Females produce gametes called *eggs* or *ova.* Male gametes are called *sperm.* Fertilization may occur after a male delivers sperm to the female's egg by means of sexual intercourse. Fertilization begins a remarkable period of development in which the egg develops into a fully formed baby within the body of the female. This period of development, called *pregnancy,* takes about nine months.

At the beginning of pregnancy, the fertilized egg is smaller than the full stop at the end of this sentence. The egg develops into a growing mass of cells called an *embryo.* Gradually, the cells rearrange themselves to form tissues. By the end of the second month of pregnancy, all the major body organs and organ systems have formed and the embryo looks distinctly human. During the rest of pregnancy, the embryo is called a *fetus.* The fetus grows while its systems prepare for the day when they must function outside the mother's body. Pregnancy ends when the new baby passes out of the mother's body at birth.

This article discusses the biological aspects of reproduction in humans. For a discussion of some of the moral and social issues related to human reproduction, see such articles as **Abortion, Baby, Birth control, Family,** and **Sex.** For information on reproduction among other living things, see **Reproduction.**

The human reproductive system

Human beings are born with the body organs needed for reproduction. But reproduction cannot actually occur until these organs mature. This maturation process takes place during *puberty,* a period of several years in which a boy or girl goes through dramatic physical changes. These changes are regulated by certain *hormones* (chemicals produced by the body). Puberty normally begins during or just before the early teenage years.

The reproductive systems of females and males differ greatly in shape and structure. But both systems are specifically designed to produce, nourish, and transport the eggs or sperm.

In females, the reproductive system consists primarily of a group of organs located within the pelvis. A woman or girl has external organs called the *vulva* be-

tween her legs. The outer parts of the vulva cover the opening to a narrow canal called the *vagina.* The vagina leads to the *uterus,* a hollow, pear-shaped, muscular organ in which a baby develops. Two small, oval organs called *ovaries* lie to the right and left of the uterus. The ovaries produce, store, and release eggs. These organs also produce two types of hormones—*progesterone* and *oestrogens.* Eggs from the ovaries reach the uterus through tubes called *fallopian tubes* or *oviducts.*

Females produce eggs as part of a monthly process called the *menstrual cycle,* which begins during puberty. Each menstrual cycle, the female reproductive system undergoes a series of changes that prepares it for fertilization and pregnancy. If the egg is not fertilized, a shedding or loss of tissue in the uterus called *menstruation* occurs. Bleeding is associated with this process and lasts three to seven days. Menstruation marks the beginning of each menstrual cycle. Each cycle lasts about 28 days. See **Menstruation.**

Other changes during a menstrual cycle involve cells in the ovaries called *oocytes.* Eggs develop from these cells. At birth, each ovary has about 400,000 oocytes. These cells remain inactive until the first menstrual cycle. Thereafter, many oocytes grow and begin to mature each month. Normally, only one oocyte in either of the ovaries reaches full maturity. This fully developed cell—the mature egg—is released from the ovary in a process called *ovulation.* This process occurs at about the midpoint of the menstrual cycle. After ovulation, the egg travels toward the uterus through one of the fallopian tubes by means of wavelike contractions of muscles and the beating of *cilia* (hairlike structures) located on cells in the walls of the oviduct. Fertilization may occur in one of the tubes. An unfertilized egg lives for about 24 hours after it leaves the ovary.

Important changes also occur in the *endometrium* (lining of the uterus). During the first half of the menstrual cycle, the ovaries release relatively large amounts of oestrogens, which cause the endometrium to thicken. The endometrium reaches its maximum thickness at about the time of ovulation. After ovulation, the ovaries release relatively large amounts of progesterone. This hormone maintains the thickness of the endometrium, so that a fertilized egg can attach to the uterus.

If fertilization occurs, the endometrium continues to develop. If fertilization does not occur, the egg breaks down and the production of progesterone decreases. The thickened endometrium also breaks down and passes out of the body during menstruation.

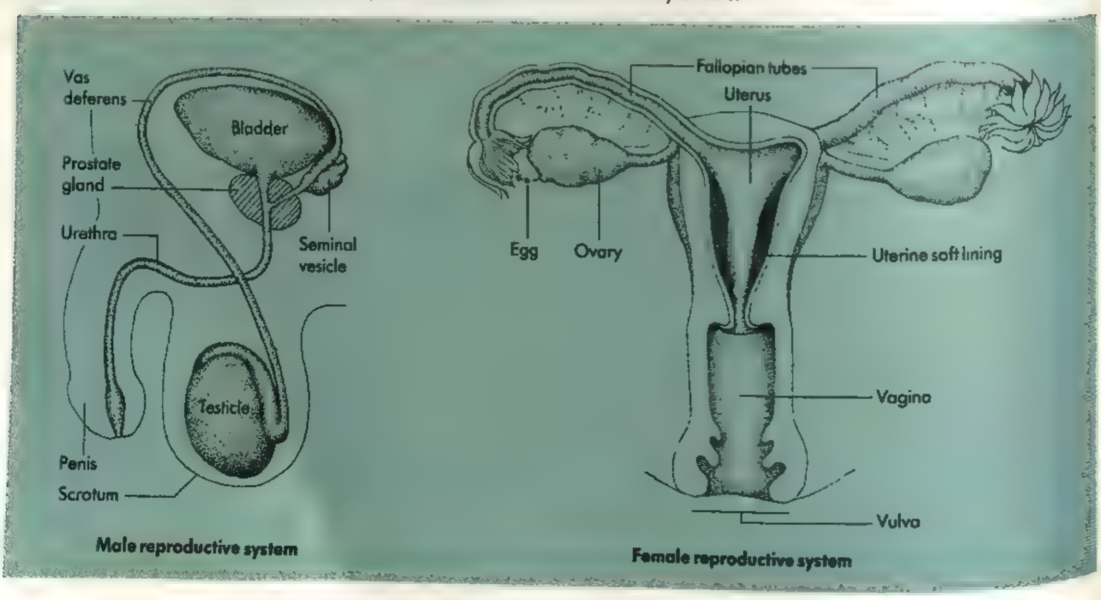
Most women produce eggs until the ages of about 45 to 55, when the menstrual cycles become increasingly infrequent and then stop. This period of a woman's life is called *menopause.* The completion of menopause marks the end of a woman's natural childbearing years.

In males, the reproductive system includes the *testicles,* a *duct system, accessory glands,* and the *penis.* The testicles, also called *testes,* are the organs that produce sperm. The duct system, which includes the *epididymis* and the *vas deferens,* transports the sperm. The accessory glands, mainly the *seminal vesicles* and the *prostate gland,* provide fluids that lubricate the duct system and nourish the sperm. The sperm leave the body through the penis, a cylindrical organ that is located between the legs.

The testicles are contained in the *scrotum,* a pouch behind the penis. The location of the scrotum keeps the testicles about 2.2 to 2.8 Celsius degrees cooler than the normal body temperature of 37.0 °C. Unlike other cells of the body, sperm cells cannot develop properly at normal body temperature. In addition to producing sperm, the testicles also produce hormones, particularly *testosterone.*

Sperm develop in the testicles within a complex system of tubes called *seminiferous tubules.* At birth, a

The human reproductive system The reproductive systems of males and females are specifically designed to produce, nourish, and transport the sperm or egg. After sperm are deposited in the vagina, they pass through the uterus and into the fallopian tubes, where fertilization usually occurs.



male baby's tubules contain only simple round cells. But during puberty, the testicles begin to produce testosterone and other hormones that make the round cells divide, and undergo changes to become slender cells with a tail. A sperm cell uses its tail, called a *flagellum,* to propel itself forward. Sperm pass from the testicles into the epididymis, where they complete their development in about 12 days and are stored.

A healthy adult male normally produces about 200 million sperm per day. Although sperm production begins to decline gradually at about 45 years of age, it normally continues throughout life.

From the epididymis, sperm move to a long tube that is called the vas deferens. The seminal vesicles and prostate gland produce a whitish fluid called *seminal fluid.* This fluid mixes with sperm to form *semen.* The vas deferens leads to the *urethra,* a tube that runs through the penis.

Semen, which contains the sperm, is expelled from the body through the urethra. This process is called *ejaculation.* The penis usually hangs limp. But when a male becomes sexually excited, special tissues in the penis fill with blood, and the organ becomes stiff and erect. When the erect penis is stimulated, muscles around the reproductive organs contract. This contraction forces fluid from the glands and propels the semen through the duct system and the urethra. The amount of semen ejaculated varies from 2 to 6 millilitres. Each millilitre of semen contains about 100 million sperm.

Fertilization

A pregnancy begins when a sperm fertilizes an egg. Fertilization, also called *conception,* normally occurs by means of sexual intercourse. Sexual intercourse takes place when the man's erect penis is inserted in the woman's vagina. When a man ejaculates, semen containing the millions of sperm is deposited in the vagina.

Scientists have developed techniques of achieving fertilization without sexual intercourse. In a process called *artificial insemination,* sperm are collected from a man and later injected into a woman's uterus. In another technique, called *in vitro fertilization,* collected sperm are used to fertilize eggs in a laboratory dish. The fertilized eggs are then inserted into the woman's uterus. See **Infertility** (Treatment).

After ejaculation, the sperm pass from the vagina into the uterus and then into the fallopian tubes. Most sperm die along the way. In each tube, only a few thousand sperm reach the *ampulla,* a section that makes up one-half to two-thirds of the tube's length. If a sperm fertilizes an egg, it usually does so in the part of the ampulla near the uterus.

Some sperm may reach the fallopian tubes in as little as five minutes. Others take hours. Sperm can survive in the fallopian tubes for up to 48 hours. It takes an egg about 72 hours to pass through a fallopian tube. The egg can be fertilized only during the first 24 hours of this period. Therefore, intercourse must take place near the time of ovulation for fertilization to occur.

The surface of a newly released egg is covered with a jellylike layer of cells called the *zona pellucida.* A second layer, called the *cumulus oophorus,* surrounds the zona pellucida. A sperm must pass through both layers to fertilize the egg. The *acrosome* (tip) of the sperm releases special enzymes that scatter the cells of both layers. Although several sperm may begin to penetrate the zona pellucida, usually only one can fertilize the egg. After the first sperm enters, the egg releases substances that prevent other sperm from entering.

How sex is determined. Fertilization is complete when the *chromosomes* of the sperm unite with the chromosomes of the egg. Chromosomes are threadlike structures that contain *genes,* the units of heredity that determine each person's unique traits. Most body cells have 46 chromosomes that occur in 23 pairs. However, as each egg or sperm develops, it undergoes a special series of cell divisions called *meiosis.* As a result, each sperm or egg cell contains only one member of each chromosome pair, or 23 unpaired chromosomes. During fertilization, the chromosomes pair up so that the fertilized egg has the normal number of 46 chromosomes. The fertilized egg is called a *zygote.*

Special *sex chromosomes* determine whether the zygote will develop into a boy or a girl. Each body cell contains a pair of sex chromosomes. In females, the two sex chromosomes are identical. Each of the chromosomes is called an *X chromosome.* The cells of males have one X chromosome and a smaller chromosome called the *Y chromosome.*

After meiosis, each sperm or egg cell has only one sex chromosome. All egg cells carry one X chromosome. Half the sperm cells carry an X chromosome, and the other half have a Y chromosome. At fertilization, a sperm with an X chromosome uniting with an egg will develop into a girl baby because the fertilized egg will have two X chromosomes. A sperm with a Y chromosome uniting with an egg will form a boy baby because the fertilized egg will have the X and Y combination. See **Heredity** (Chromosomes and genes).

Multiple birth. In most cases, a single egg is fertilized and develops into one baby. Occasionally, however, two or more infants develop and are born at the same time. The birth of more than one baby from the same pregnancy is called *multiple birth.*

Multiple births can result from separate zygotes or from a single zygote. For example, if two eggs are released during ovulation, each may be fertilized by a separate sperm, producing separate zygotes. The two zygotes develop into *dizygotic twins,* also called *fraternal twins. Monozygotic twins* develop from a single zygote that divides into separate cells, with each cell developing independently. The infants born have the same genetic makeup and usually resemble each other. Such twins are also called *identical twins.* See **Multiple birth.**

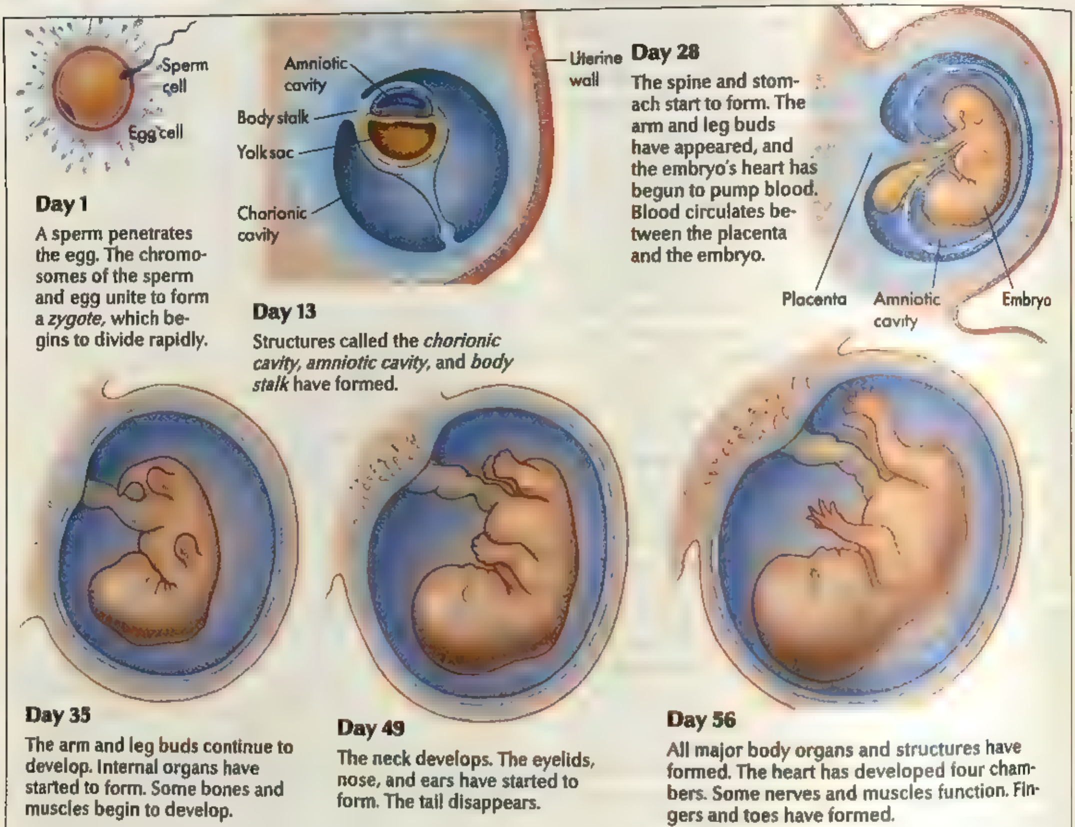
Development of the embryo

The zygote goes through a series of changes before it reaches the uterus. In the uterus, the zygote develops into a form called the embryo. The embryo develops rapidly. Within two months, all the tissues and organs of the body have begun to form.

The first days of pregnancy. After fertilization, the zygote travels through the fallopian tube toward the uterus. Along the way, the zygote begins to divide rapidly into many cells with no increase in overall size. The resulting cell mass is called a *morula.* By the third or fourth day after fertilization, the morula enters the uterus. At that time, the morula is still surrounded by the

The development of a human embryo

During the first two months of pregnancy, an embryo develops from a single cell to a recognizably human shape about 3 centimetres long. After this period, the embryo is called a *fetus.*



Day 1
A sperm penetrates the egg. The chromosomes of the sperm and egg unite to form a *zygote,* which begins to divide rapidly.

Day 13
Structures called the *chorionic cavity, amniotic cavity,* and *body stalk* have formed.

Day 28
The spine and stomach start to form. The arm and leg buds have appeared, and the embryo's heart has begun to pump blood. Blood circulates between the placenta and the embryo.

Day 35
The arm and leg buds continue to develop. Internal organs have started to form. Some bones and muscles begin to develop.

Day 49
The neck develops. The eyelids, nose, and ears have started to form. The tail disappears.

Day 56
All major body organs and structures have formed. The heart has developed four chambers. Some nerves and muscles function. Fingers and toes have formed.

zona pellucida and consists of about 12 to 16 cells.

The embryo develops from the central cells of the morula. These cells are called the *inner cell mass.* The outer cells of the morula are called the *outer cell mass.* They develop into the *placenta,* an organ that connects the embryo to the blood supply of the mother.

After the morula enters the uterus, it continues to divide. A fluid-filled cavity forms between one side of the inner cell mass and the outer cell mass, and the zona pellucida begins to disintegrate. At this stage, the ball of cells is called a *blastocyst* or *blastula.* The cells of the blastocyst divide as it floats free in the uterus for one or two days.

About the fifth or sixth day of pregnancy, the blastocyst becomes attached to the internal surface of the uterus. The outer cells of the blastocyst, called the *trophoblast,* secrete an enzyme that breaks down the lining of the uterus. The trophoblast begins to divide rapidly, invading the uterine tissue. The process of attachment to the uterine wall is called *implantation.* By the 11th day of the pregnancy, the blastocyst is firmly implanted in the uterus.

Nourishing the embryo. Various structures develop in the uterus to help the embryo grow. These structures include the placenta and certain membranes.

By the 13th day of pregnancy, a space called the *chorionic cavity* has formed around the embryo. Two membranes surround the chorionic cavity. The outer membrane is called the *chorion,* and the inner membrane is called the *amnion.* The chorion interacts with tissues of the uterus to form the placenta. The chorion pushes into the wall of the uterus with fingerlike projections called *chorionic villi.* The chorionic villi contain the embryo's first blood vessels. The chorion is attached to the embryo by a structure called the *body stalk.* The body stalk develops into the *umbilical cord,* which joins the embryo to the placenta.

The amnion forms a sac around the embryo and is filled with fluid. The embryo floats in this fluid, called *amniotic fluid.* The amniotic fluid protects the embryo by absorbing jolts to the uterus. It also allows the embryo to move without damaging the amnion and other tissues.

About the 21st day of pregnancy, blood begins to circulate between the placenta and the embryo. The blood vessels of the mother and those of the embryo exchange substances through a thin layer of cells called the *placental barrier.* Waste products from the embryo are carried away through the barrier. Likewise, nutrients and oxygen from the mother's blood pass through the thin walls of the barrier and enter the embryo's blood. However, such organisms as viruses and bacteria, as well as chemical substances, including drugs, also may cross the placental barrier and harm the embryo.

Origin of tissues and organs. At about the same time that the placenta begins to form, the inner cell

mass flattens and develops into three layers of cells in what is called the *embryonic disc.* The three types of cell layers are the *ectoderm,* the *mesoderm,* and the *endoderm.* In a process called *differentiation,* cells from each layer move to certain areas of the embryonic disc and then fold over to form tubes or clusters. These tubes and clusters develop into various tissues and organs of the body.

Cells from the ectoderm form the brain, nerves, skin, hair, nails, and parts of the eyes and ears. Cells from the mesoderm form the heart, muscles, bones, tendons, kidneys, glands, blood vessels, and reproductive organs. The linings of the digestive and respiratory systems develop from cells of the endoderm.

Development of organs and organ systems. The body's organs and organ systems grow rapidly from the third to eighth weeks of pregnancy. The major structures include the central nervous system and the circulatory system, as well as such organs as the eyes, ears, and limbs. Defects in the development of these structures often occur during these weeks. Such defects sometimes are caused by substances introduced from the mother's body through the placental barrier. These substances are called *teratogens.* They include medications taken by the mother, as well as viruses, bacteria, and other infectious organisms. Other teratogens include nonmedicinal drugs, alcoholic beverages, and cigarette smoke.

The central nervous system, which consists of the brain and spinal cord, starts to develop in the middle of the third week of pregnancy. It begins as a flattened strip of cells within a long cylinder of cells called the *neural tube.* At about the 25th day of pregnancy, one end of the neural tube closes. The brain develops from three sacs formed in this end of the tube. The other end of the tube closes two days later. Failure of the tube to close can result in birth defects, especially *spina bifida,* a disorder of the spine.

The circulatory system also begins to develop in the third week of pregnancy. Two tubes of cells combine to form a single tube that becomes the heart. By the fourth week, a simple circulatory system is functioning and the heart has begun to pump blood. During the fourth to seventh weeks of pregnancy, the heart tube divides into four chambers. Any irregularity in the normal pattern of development during this period can produce a defect in the heart.

The eyes and ears begin to develop in the fourth week of pregnancy. Both these organs form rapidly. The external parts of the ears appear by the sixth week. Defects in the eyes or ears often stem from abnormalities that occur during the fourth to sixth weeks.

The arms and legs appear as buds of tissue during the fifth week of pregnancy. The arms begin to develop a few days ahead of the legs. The fingers and toes will become recognizable in the sixth week. They form when certain cells die and leave spaces in the remaining tissue.

The structures of the mouth, such as the lips and palate, begin to form during the fourth and fifth weeks of pregnancy. The lips and palate form during the sixth to ninth weeks. Each forms from paired structures that gradually move from the sides toward the middle of the face and *fuse* (join). If anything interferes with normal development during this period, a split in the upper lip or palate may develop. Such a defect is called *cleft lip* or *cleft palate.* See **Cleft palate.**

Growth of the fetus

From the ninth week of pregnancy until birth, the developing baby is called a fetus. In the first three months of this period, the fetus increases rapidly in length. It grows about 5 centimetres in each of these months. In the later months of pregnancy, the most striking change in the fetus is in its weight. Most fetuses gain about 700 grams in both the eighth and ninth months of pregnancy.

Stages of growth. Doctors commonly divide pregnancy into three, three-month parts called *trimesters.* At the end of the first trimester, the fetus weighs about 28 grams and is about 7.5 centimetres long. At the end of the second trimester, the fetus weighs about 850 grams and measures about 35 centimetres long. At the end of the third trimester, the fetus measures about 50 centimetres and weighs about 3.2 kilograms.

The mother can feel movements of the fetus by the fifth month of pregnancy. By this time, fine hair called *lanugo* covers the body of the fetus. Hair also appears on the head. Lanugo disappears late in pregnancy or shortly after birth. The eyelids open by the 26th week of pregnancy. By the 28th week, the fingernails and toenails are well developed.

Until the 30th week of pregnancy, the fetus appears reddish and transparent because of the thinness of its skin and a lack of fat beneath the skin. In the last six to eight weeks before birth, fat develops rapidly and the fetus becomes smooth and plump.

The mother also experiences many physical changes during pregnancy. For example, a pregnant woman gains weight and her breasts increase in size. For more information on such changes, see **Pregnancy.**

Checking the fetus. Doctors can use several procedures to monitor the development of the fetus in the mother's uterus. Two of the most commonly used techniques are *ultrasonography* and *amniocentesis.*

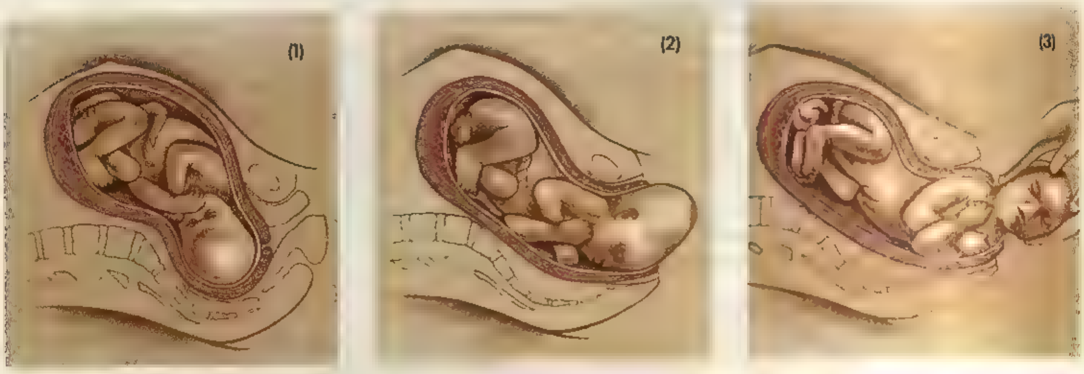
Ultrasonography, also called *ultrasound,* involves the use of high-frequency sound waves to produce an image of the fetus on a screen. By viewing the shape and body features of the fetus, a doctor can measure its growth and detect malformations. Fetal abnormalities also can be detected through amniocentesis. This technique involves the removal of a sample of the amniotic fluid, which contains cells of the fetus. The fluid and cells are then analysed and examined. See **Amniocentesis; Ultrasound.**

Birth

The process of giving birth is called *parturition* or *labour.* By this process, the fetus and the placenta are pushed out of the uterus. Scientists believe that labour is triggered by the release of certain hormones from the adrenal glands of the fetus.

A fetus that undergoes the normal period of development before labour begins is considered to have reached *term.* Labour occurs at term if it begins during the 37th to 43rd week of pregnancy. Labour that starts before the 37th week is called *preterm labour.* Labour that begins after the 43rd week is *postterm labour.* Ba-

The birth of a baby Before birth (1), the head of the baby lies near the opening of the uterus. As muscle action forces the baby out of the uterus (2), the head turns and (3) the baby passes through the vagina.



bies born at term or postterm have the best chance for survival. Most babies born from the 26th to 36th weeks of pregnancy also will live, but some of these babies may experience serious health problems because their respiratory and central nervous systems are not fully developed at birth. Babies born before the 26th week have a poor chance of surviving.

The stages of labour. Labour has three stages. The first stage begins with an alternating tensing and relaxing of muscles in the uterus. These muscle contractions are called *labour pains.* When labour begins, the fetus lies within its protective membranes and is held in place by the *cervix* (neck of the uterus). During the first stage of labour, the cervix begins to *dilate* (open). This stage ends when the cervix has fully dilated to a diameter of about 10 centimetres. The first stage of labour is the longest, averaging about 14 hours in women giving birth for the first time. In women who have had children before, this stage normally takes 8 hours or in some cases less.

The second stage of labour begins at full dilation of the cervix and ends with the delivery of the baby. This stage may last from one to five hours. The muscle contractions of the uterus and abdomen help push the baby through the cervix and out the vagina. Most babies are born headfirst, but some are born with their shoulders or buttocks first. After the head comes out, the rest of the baby follows easily.

The third stage of labour starts after the baby's delivery and ends when the placenta, now called the *afterbirth,* is expelled from the uterus. This stage lasts about 30 minutes. A few minutes after the baby is born, the umbilical cord is clamped and cut. The placenta then detaches from the uterus and passes out the vagina.

Sometimes, the smallness of a woman's pelvis or some other condition makes it difficult to deliver a child through the vagina. In these situations, doctors may perform surgery to remove the baby through the mother's abdomen. This procedure is called a *Caesarean section.* See Childbirth.

The newborn infant. At birth, most babies weigh about 3.2 kilograms and measure about 50 centimetres long. The newborn infant is fed with the mother's breast milk or with a formula of milk and other nutrients. The baby can now survive outside its mother's body but needs constant care.

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Miscarriage
Multiple birth
Ovary
Penis
Placenta
Pregnancy
Prostate gland
Sex
Sexually transmitted disease
Sterility
Testicle
Uterus
Vagina

Outline

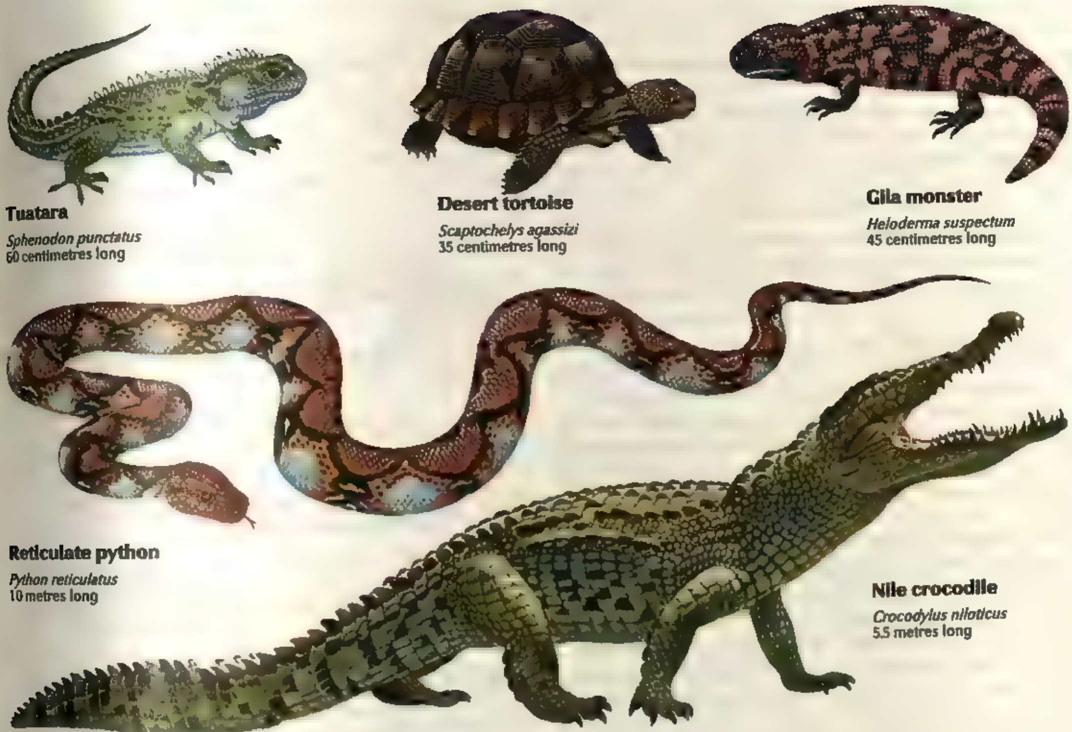
I. **The human reproductive system**
   A. In females
   B. In males
II. **Fertilization**
   A. How sex is determined
   B. Multiple birth
III. **Development of the embryo**
   A. The first days of pregnancy
   B. Nourishing the embryo
   C. Origin of tissues and organs
   D. Development of organs and organ systems
IV. **Growth of the fetus**
   A. Stages of growth
   B. Checking the fetus
V. **Birth**
   A. The stages of labour
   B. The newborn infant

Questions

What are the three stages of labour?
How many chromosomes does a fertilized egg have?
What is *lanugo?*
How long does an egg survive after being released by an ovary?
Where in a woman's body does fertilization usually occur?
What is *menopause?* When does it occur?
How long does pregnancy last?
What are *dizygotic twins? Monozygotic twins?*
How does a sperm propel itself?
What are *teratogens?*

Reptile is an animal that has dry, scaly skin and breathes by means of lungs. There are about 6,500 *species* (kinds) of reptiles, and they make up one of the classes of *vertebrates* (animals that have a backbone). Reptiles include alligators, crocodiles, lizards, snakes, turtles, and the tuatara.

Reptiles are cold-blooded—that is, their body temperature stays about the same as the temperature of their surroundings. To stay alive, these animals must avoid extremely high or low temperatures. Most reptiles that are active during the day keep moving from sunny places to



Reptiles vary greatly in size, shape, and colour. However, they all have skin that consists of dry, tough scales. There are about 6,500 species of reptiles. Most of these animals live on land, but some make their home in the ocean and others dwell in fresh water.

shady spots. Many species of reptiles that live in hot climates are active mainly at night. Reptiles in regions that have harsh winters hibernate during the winter.

The various species of reptiles vary greatly in size. For example, pythons grow more than 9 metres long, and leatherback turtles may weigh nearly 1 metric ton. On the other hand, some species of lizards measure no more than 5 centimetres long.

Many reptiles live a long time, and some turtles have lived in captivity for more than 100 years. For the length of life of various other reptiles in captivity, see **Animal** (table: Length of life of animals).

Reptiles live on every continent except Antarctica and in all the oceans except those of the polar regions. They are most abundant in the tropics. Many kinds of lizards and snakes thrive in deserts. Many other snakes live in forests. Pipesnakes and some boas burrow underground. Other reptiles, including marine iguanas and sea turtles, spend much of their life in the ocean. Some sea snakes spend their entire life in the water.

Many people are afraid of reptiles, but most species are harmless and avoid human beings if possible. The Nile crocodile and the saltwater crocodile may attack and kill people. The Gila monster, the Mexican beaded lizard, and several snakes, including cobras, rattlesnakes, vipers and tigersnakes, have *venomous* (poisonous) bites.

In many parts of the world, people eat reptiles and reptile eggs. Some reptiles, including alligators, crocodiles, lizards, and snakes, are hunted for their skin. Manufacturers use the skin as leather for belts, shoes, and other products. Many countries now prohibit the import of the hides of those reptiles classified as endangered species.

Kinds of reptiles

Zoologists divide reptiles into four main groups: (1) lizards and snakes, (2) turtles, (3) crocodilians, and (4) the tuatara.

Lizards and snakes make up the largest group of reptiles. There are 3,750 species of lizards and about 2,400 species of snakes. Most lizards have four legs, long tails, movable eyelids, and external ear openings. A few species, such as glass snakes and slow worms, have no legs. Lizards thrive in regions that have a hot or warm climate. These animals are also common in deserts.

Snakes have tails that vary in length, depending on the species. But snakes have no legs, eyelids, or ear openings. An unmovable covering of transparent scales protects their eyes. Snakes live mostly in the tropics and in warm regions. However, the European viper lives north of the Arctic Circle, in Finland and Sweden.

Turtles are the only reptiles with a shell. They pull their head, legs, and tail into the shell for protection. There are about 250 species of turtles. They live on land, in fresh water, and in the ocean.

Crocodilians include alligators, caymans, crocodiles, and gavials. There are about 25 species of crocodilians, all of which live in or near water. These reptiles have a long snout, strong jaws, and webbed hind feet. They use

their long, powerful tail to swim. All except a few crocodilians dwell in the fresh waters and lowlands of the tropics. Alligators live in Southern China and the Southeastern United States.

The tuatara inhabits several islands off the coast of New Zealand. It looks like a lizard but is more closely related to the extinct dinosaurs.

The body of a reptile

Reptiles vary greatly in size, shape, and colour, but all of them share certain physical characteristics. These characteristics, in addition to the animals' being cold-blooded, include various features of the skin, skeleton, internal organs, and sense organs.

Skin of a reptile consists of scales. Lizards and snakes have a single sheet of overlapping scales. The scales of turtles, crocodilians, and the tuatara grow in the form of individual areas called *plates.* Crocodilians and some lizards have pieces of bone called *osteoderms* within their scales. The skin of such reptiles serves as protective armour.

Many species of reptiles shed their skin several times a year. New scales form under the layer of scales and loosen it. Among snakes, the skin on the snout loosens first. The snake pushes this skin backwards against a rock or the stem of a plant. The animal then crawls out of the old skin and sheds it in one piece. Most lizards shed their skin in large strips, and the skin of crocodilians wears away gradually.

Skeleton of reptiles provides a framework for the head, trunk, and tail. Most reptiles have hip and shoulder bones called *girdles* that support the legs. The majority of snakes do not have girdles. The hip and shoulder girdles of turtles, unlike those of any other animal, are inside the ribcage. The ribs and vertebrae make up the inner layer of the turtle's shell.

Internal organs. Reptiles breathe by means of lungs. Most species have two lungs, but some snakes have only one. The digestive system of reptiles varies among the species, according to the kind of food the animal eats. Reptiles that feed mainly on animals or on such animal products as eggs have a fairly simple stomach and a long intestine. Such reptiles include boa constrictors and Gila monsters. Species that eat plants, including iguanas and most tortoises, have a more complicated stomach. Species of the crocodilian group have extremely large stomach muscles that grind flesh into tiny pieces.

Venomous reptiles produce their venom by means of a gland in the mouth. The venom affects the victim's circulatory system or nervous system.

Sense organs. Most reptiles have good vision. Species active during the day have eyes with round pupils. Most species active at night have slitlike eye pupils, which can be closed almost completely in bright light.

The hearing of reptiles varies among the species, but most can hear at least low-pitched sounds. The majority of reptiles have an eardrum, a middle ear, and an inner ear. However, snakes lack a middle ear and cannot hear sounds carried through the air. They "hear" by sensing vibrations from the ground.

Snakes and lizards have two tiny cavities called the *Jacobson's organ* in the roof of the mouth. The animals pick up particles from the air and the ground with their

Interesting facts about reptiles

Cold-blooded animals. Reptiles are cold-blooded—that is, their body temperature rarely differs much from the temperature of their surroundings. Reptiles that are active on hot, sunny days cool off by moving to shady spots.

The skin of reptiles. Lizards and snakes have a single sheet of overlapping scales, *left.* Other reptiles grow *plates* (separate areas of scales), *right.* The main function of the skin is to keep water in the animal's body. Reptiles can go without water for long periods, and many species thrive in deserts.

Moulting. Many kinds of reptiles *moult* (shed their skin) several times a year. The skin loosens after new scales form under it. The skin of lizards comes off in large strips, as shown at the right.

The shape of a reptile's pupil indicates whether the animal is active at night or during the day. Most reptiles active at night have slitlike pupils that can be closed almost completely in bright light. Reptiles active in daytime have round pupils. Most reptiles have good vision, and some can tell the difference between colours.

Egg-laying reptiles include alligators, crocodiles, turtles, a number of snakes and lizards, and the tuatara. The eggs are laid in decayed wood, a nest of leaves and mud, or elsewhere on land. Heat from the sun causes the eggs to hatch.

Dinosaurs, the most spectacular reptiles, dominated land animals for millions of years. These creatures died out about 65 million years ago. The diplodocus, *above,* a plant-eating dinosaur that measured about 27 metres long, was one of the largest animals that ever lived.

tongue and put them into this organ. The cavities are lined with sensitive tissue that aids the sense of smell. Pit vipers have special nerves in two depressions near the snout. The nerves are sensitive to heat—including the body heat of birds and mammals—and help the snakes hunt these animals as prey.

Ways of life

Reproduction. Most reptiles reproduce sexually. The male releases *sperm* (male sex cells) into the female opening that leads to the reproductive organs. In a process called *fertilization,* the sperm unite with *eggs* (female sex cells) within the female's body. The fertilized eggs then develop into new animals.

Most reptiles mate during the spring, and the young are born in summer. All turtles, crocodilians, and the tuatara, as well as some lizards and snakes, are *oviparous* —that is, the female lays eggs that have shells. She lays her eggs in rotten wood, a hole in the ground, or elsewhere on land. Because the egg has a watertight shell it can be laid in a dry place and the nutrients inside the shell will not dry out. Heat from the sun—and, in some cases, from rotting plant matter—*incubates* (warms) the eggs, causing them to hatch. Some snakes and lizards are *ovoviviparous.* Among these species, the female protects the eggs within her body until they hatch. A few species of snakes and lizards are *viviparous.* The unborn young of these species receive nourishment through the *placenta,* a structure that attaches them to the female's body. The young of ovoviviparous and viviparous reptiles are born alive.

Only a few species of reptiles provide care for their eggs or young. Among pythons, mud snakes, and some skinks, the female wraps her body around the eggs and protects them. A female alligator carries her newly hatched young to water in her mouth.

Food. Most reptiles eat other animals, and they prey on almost any creature they can catch. However, some lizards and turtles eat mainly plants. Other reptiles eat only certain animals or animal products. For example, map turtles eat freshwater clams and snails, and African egg-eating snakes feed on birds' eggs.

Most reptiles simply grab their food and either chew it or swallow it whole. Crocodilians may first drown their prey. Venomous reptiles paralyse victims by biting them. Pythons, king snakes, and rat snakes suffocate prey by wrapping themselves around it. Reptiles can go without food for long periods. After a snake eats a large meal, it might not feed again for several weeks.

Protection. The chief enemies of reptiles include birds, mammals, and other reptiles. Most of the enemies prey on small or young reptiles. Large adult reptiles generally are safe from all attackers except people.

Reptiles avoid their enemies in a variety of ways. Many reptiles have protective coloration that blends with their surroundings and makes them hard to see. Several kinds of lizards, such as chameleons and anoles, can change colour to match their surroundings. Other reptiles bluff or play tricks to avoid attack. For example, if a hognose snake is approached, it rolls over on its back and lies completely motionless. The snake plays dead until the attacker goes away.

Most reptiles fight by biting and scratching, and some of the larger species inflict deep wounds. Crocodilians and large lizards strike sharp blows with their powerful tail, which they use as a whip. The bite of a venomous reptile can be fatal.

Hibernation. Reptiles that hibernate in winter do so by burrowing into the ground or slipping into a crack between two rocks. They stay there until the weather warms up. Before hibernating, a reptile eats a lot of food, which forms a layer of fat in its body. The fat serves as food during hibernation.

Reptiles that live in the tropics sometimes enter an inactive state during dry periods, when food becomes scarce.This type of inactivity, called *aestivation,* resembles hibernation.

The evolution of reptiles

The oldest fossils of reptiles date back to the Pennsylvanian Period—from 330 million to 290 million years ago. Reptiles *evolved* (developed slowly) from amphibians, which live near water because their eggs must be laid in a moist place. The eggs of amphibians dry up quickly on land. Reptiles developed eggs with thick shells and membranes, which prevent loss of moisture. As a result, reptiles can live away from water.

Reptiles became the dominant animals on land during the Mesozoic Era—from 240 million to 63 million years ago. This period is called the *Age of Reptiles.* The most spectacular of all reptiles, the dinosaurs, appeared early in the Mesozoic Era. The gigantic plant-eating dinosaurs, such as *Ultrasaurus* and *Seismosaurus,* were the largest land animals that ever lived. The ferocious *Tyrannosaurus* dominated the flesh eaters that lived on land. Other reptiles of the period included the fishlike ichthyosaurs and the birdlike pterodactyls.

Dinosaurs died out at the end of the Mesozoic Era. Scientists do not know why these creatures became extinct. However, changes in the climate may have altered the food supply of the plant-eating dinosaurs. As the plant eaters died out, the flesh-eating dinosaurs that preyed on them also disappeared. Mammals probably contributed to the disappearance of dinosaurs by eating dinosaur eggs.

Through the centuries, more and more species of reptiles became extinct. Today, the future of wild reptiles is threatened by the continual need of people for more farmland and living space. This need may destroy the habitats of many species of reptiles and thus wipe out the animals themselves. Other species are endangered by continued hunting and egg collecting. The survival of a number of species depends on conservation action by governments and individuals.

Related articles in *World Book* include:

Reptiles

See **Lizard** and **Snake** with their *Related articles.* See also:

Alligator	Gavial	Tortoise	Turtle
Crocodile	Terrapin	Tuatara	

Other related articles

Cold-blooded animal	Herpetology
Dinosaur	Hibernation
Fossil	

Reptiles, Age of. See **Dinosaur; Prehistoric animal** (The Age of Reptiles).

Republic is any form of government whose leader or leaders are elected, usually for a specific term of office.

The word *republic* also refers to a country that has an elective form of government.

The idea of a republic is sometimes associated with the notion of a *democratic republic.* In a democratic republic, the people as a whole exercise important controls over their elected leaders through elections, lobbying, and other processes. The leaders are expected to represent the interests of the people who elected them. If the voters believe that their interests have not been represented well enough, they may decide not to reelect the leaders. In this way, the voters have some control over their government.

There are many other kinds of republics besides democratic republics. In some republics, the leaders are elected by a relatively small number of people and may be reelected more or less automatically. For example, Communist nations traditionally allowed only candidates approved by the Communist Party to run for election, and there was only one candidate for each post. As a result, voters had no real choice of candidates when they went to the polls. However, in August 1991, the Communists lost control of the government of the Soviet Union, and in December of that year, the Soviet Union broke up. As a result such practices are no longer followed in the new independent states or in the nations of Eastern Europe, but they are still in effect in China and a few other Communist countries. In some countries that are republics according to their constitutions, elections typically are not free, open, or honest. In some Latin-American republics, for example, charges of vote fraud accompany nearly every election.

The most important early republic was the one established in Rome in 509 B.C. This republic lasted until 27 B.C., when the political and military leader Augustus named himself emperor. When the United States was founded in 1776, it became the only major country at the time with a republican form of government.

Today, many of the countries of Western Europe are republics, including France, Ireland, and Italy. Many African and Asian nations are republics, as are all Latin-American countries. The Commonwealth of Nations, an association of nations that includes the United Kingdom and many of its former possessions, has numerous members that are republics (see **Commonwealth of Nations** [table: Independent members]).

See also **Democracy; Government.**

Republic, The. See **Plato.**

Republican Party is one of the two principal political parties of the United States. The other is the Democratic Party. The Republican Party is often called the *G.O.P.,* which stands for *Grand Old Party,* a nickname Republicans gave their party in the 1880's.

The Republican Party has greatly influenced the history and politics of the United States. It won 14 of the 18 presidential elections from 1860, when Abraham Lincoln was elected, to 1932. From 1932 to 1992, it won 7 of the 16 presidential elections.

The origin of the Republican Party dates back to the antislavery movement in the United States during the 1850's. The Republican Party was formally given its name on July 6, 1854. Few Southerners supported the Republicans. However, after promising new federal programmes and the opening of Western land for settlement, the Republicans gained popularity. Abraham Lincoln won the presidency for the party in 1860. During the American Civil War (1861-1865), the Republicans used the name *Union Party,* or *National Union Party.* After the war, some Republicans favoured harsh punishment for the defeated Southern states. During the late 1800's, Republicans passed land legislation that appealed to farmers, and won the backing of business leaders by endorsing sound money policies and high tariffs. The party became a firm alliance of people in the agricultural Western states and the industrial East. The elephant first appeared as a Republican symbol in an 1874 cartoon and remains the party's symbol.

Theodore ("Teddy") Roosevelt was a popular Republican president of the early 1900's. His successor was William Howard Taft. When Roosevelt again sought the presidency in 1912, the Republican Party was split, and Woodrow Wilson, a Democrat, won the election.

By 1918, the Republicans had reunited and gained control of the U.S. Congress. The Republican-controlled Senate rejected American membership of the League of Nations (see **League of Nations**). During the 1920's the Republicans won every presidential election, with Warren Harding, Calvin Coolidge, and Herbert Hoover serving as presidents.

Hoover lost in 1932 to the Democratic candidate, Franklin Roosevelt. From 1933 to 1953, the Republican Party was the minority party. Many Republicans shifted away from support for anti-foreign, anti-welfare programmes, and accepted the idea of government-funded welfare, and of U.S. leadership in world affairs. They also accepted American membership of the United Nations, formed in 1945.

In 1952 Dwight Eisenhower easily won the presidency for the Republicans, defeating Adlai Stevenson. Eisenhower won again in 1956, once more beating Stevenson. After Eisenhower left office in 1961, the Republicans again fell out of power. The party suffered a major setback in 1964 when Barry Goldwater, leader of the conservative Republicans, lost overwhelmingly in his bid for the presidency. Other setbacks came in 1974, when President Richard Nixon resigned, and in 1976, when President Gerald Ford failed to win a full term. But Republican Ronald Reagan won the presidency in 1980 and 1984. George Bush, Reagan's vice president, was elected president in 1988, but he lost his bid for a second term in 1992.

See also: **Democratic Party; Political party; President of the United States; United States, History of the.**

Resaca de la Palma, Battle of. See **Mexican War** (Principal battles).

Research is the systematic investigation of a particular subject. In science, *research* usually refers to efforts to discover new knowledge or to develop new processes or products. In some cases, especially in fields other than science, *research* means the collection of information that already exists. For example, a lawyer might be said to research the laws and earlier court decisions that relate to a case. An author writing a biography of a famous person might read that person's letters, diaries, and other writings. The author might do this to collect details of the person's life, or to help form a picture of his or her personality. This article deals mainly with research in science. For information on how to use reference books and other sources to prepare an essay,

Basic research aims at a better understanding of a subject. This researcher is using genetic engineering techniques in an attempt to produce hardier, higher-producing maize plants.

Applied research aims at a practical goal, such as creating a new product or improving an existing one. This car-crash test contributes to the development of safer cars.

school project, or other assignment, see *A Student Guide to Better Writing, Speaking, and Research Skills* in the Index, Volume 22.

Researchers explore a wide variety of topics. Some investigate the origin of the universe. Many develop new materials for particular industrial uses. Others examine the molecules that make up the cells of plants or animals. Some researchers try to find ways to detect and cure cancer or other diseases. Other researchers try to discover how to prevent crime or study what makes people buy certain products.

Research in one branch of science often helps research in another. For example, advances in communication and the development of computers have played important roles in the exploration of outer space. Dating methods developed by researchers in the physical sciences help archaeologists estimate the age of prehistoric fossils and other remains.

The importance of research may be judged from the many new products and services it has produced. For example, research in chemistry has led to new ways of using crude petroleum to make improved fuels, rubber, plastics, and fibres. Chemical research has also led to new materials used in rockets and other space vehicles. Biological research has produced such modern medical techniques as blood transfusions, X-ray diagnosis, and the electrical recording of heart and brain activity. Biological research also has led to drugs that relieve pain, fight infections, or control heart disease.

New products and services made possible by research have created the highest standard of living in history. Such advances have helped many people live longer and more comfortably than ever before. However, some people believe research can also have harmful effects. In the 1970's and 1980's, for example, some people feared that biological research would produce new disease-causing bacteria or viruses that were resistant to drugs.

From earliest times, a small number of people have carefully observed things in nature and thought deeply about them. These people were known as *natural philosophers.* A few natural philosophers carried the process further. They not only observed things in nature but also formed theories about them. They then checked their ideas by experimentation. These developments helped lay the foundation for the beginning of modern science and modern scientific research during the 1500's and 1600's.

Over the years, research has grown from the experiments of a few pioneers until it has become an activity vital to the health, security, and prosperity of society. In modern industrialized countries, research requires the talent and skill of thousands of scientists and technicians, and the expenditure of vast sums of money. But research is essential to help us understand the universe, to increase the quality of life, and to provide improved products and services.

Kinds of research

There are two types of research. They are (1) basic research, which is sometimes called simply *research,* and (2) applied research, which is sometimes called *development.*

Basic research aims at a better understanding of a particular subject. The investigations need not have any practical use. Basic research explores such questions as: "What is the structure of an atom?" "How do plants use energy from the sun?" and "How does the human memory work?"

In many cases, information provided by basic research plays an essential role in solving practical problems. For example, the British physicist James Clerk Maxwell conducted basic research to determine relationships between heat and other forms of energy. Maxwell expressed his findings in mathematical formulas. Today, applied researchers use these formulas to de-

sign cars and even rocket engines that use fuel more efficiently.

The German-born physicist Albert Einstein explored in his research the relationships between energy and matter. His famous equation $E=mc^2$ enabled scientists to calculate the energy released by nuclear reactions.

Two physicists, the New Zealand-born Ernest Rutherford and Niels Bohr of Denmark, each conducted research on the structure of atoms. The theoretical knowledge gained from their work eventually helped applied researchers develop improved metals for the construction of spacecraft and other vehicles.

Applied research aims at a practical goal, such as the development of a new product or the improvement of an existing one. Because of its immediate usefulness to industry, applied research is more widespread than basic research. Applied research includes efforts to use energy from the sun in new ways and to develop less costly manufacturing processes. It also includes studies to find the most effective way in which to advertise a product.

In some cases, applied research depends largely on trial and error. For example, the American inventor Thomas Edison conducted hundreds of experiments to find a suitable filament for an incandescent light bulb.

In other cases, applied research depends mainly on new findings from basic research. For example, the discovery of X rays in basic research provided the basis for the applied research that developed X-ray machines. In turn, applied research often helps basic research. For example, X-ray machines have been used in basic research to examine the arrangement of atoms in crystals and other substances. Computers, also developed through applied research, play an important role in many types of basic research.

Many scientists have engaged in both basic and applied research. Basic research conducted by Louis Pasteur, a French chemist, helped establish the science of *microbiology* (the study of microscopic organisms). But Pasteur also made major contributions to the wine and silk industries with his applied research on the preservation of wine and the prevention of disease in silkworms.

The Italian-born physicist Enrico Fermi did basic theoretical work on nuclear particles during the 1930's. During the 1940's, however, he applied his knowledge to help construct an atomic *pile* (reactor), which produced the first laboratory chain reaction.

How a researcher works

The work of a researcher varies with the topic and purpose of the research. However, most research consists of some or all of the following steps: (1) defining the problem, (2) studying existing information, (3) forming a *hypothesis* (proposed explanation), (4) collecting evidence, and (5) drawing a conclusion.

Defining the problem may take only a few sentences or it may take hundreds of words. A detailed definition may result in a better understanding of the problem. In applied research, the definition includes any limiting conditions on the solution. For example, a manufacturer of power lawn mowers might research the problem of how to reduce engine noise. The manufacturer might impose the limiting condition that the solution must not raise the cost of producing the lawn mower.

Studying existing information is a key activity in the work of a researcher. This U.S. meteorologist relies on computers to speed up his study of data used to monitor and predict hurricanes.

Studying existing information may begin with the reading of several books or articles related to the problem. A researcher doing such reading may make a list of key words in the field and of authors who have written on the subject. A librarian uses the list to search a computerized information bank. The search produces a printout that may list hundreds of articles or patents related to the researcher's problem. Most printouts list the title, the author, and an *abstract* (summary) of each article. The researcher then carefully studies the most helpful articles or patents.

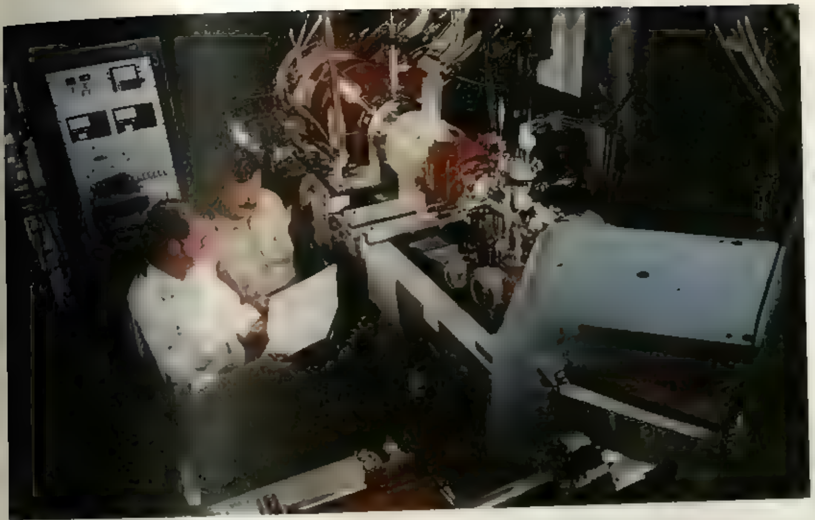
Forming a hypothesis. Researchers use existing information to form a hypothesis. They strive to form hypotheses that explain, unify, or organize known facts. A good hypothesis also opens new areas of research.

Collecting evidence. In many types of research, experiments are used to collect evidence. Some research requires specially designed equipment. For example, the cloud chamber and bubble chamber are highly sophisticated devices designed to detect the electrons and other particles within an atom. Some researchers use simple, ready-made equipment to discover new information. The American biologists Alfred D. Hershey and Martha Chase used an ordinary kitchen blender for a famous study of the viruses that infect bacteria.

In sciences that deal with the behaviour of individuals or groups of people, *surveys* and *field observations* are often used to collect evidence. A survey is a study that measures people's attitudes and activities by asking questions of the people themselves. In field observation, the researcher studies a community or other group, often by living among the people and participating in their daily lives.

Drawing a conclusion may require logic, statistical techniques, or both to draw together and analyse the results of experiments, surveys, or field observations. Computers often aid in the analysis of large amounts of information.

Once the researcher has formed a conclusion, what he or she does with it may depend on whether the study



Research equipment, such as the apparatus in this laboratory, often requires huge investments. Funds come mainly from governments and businesses.

was basic or applied research. Basic researchers submit many of their findings to scientific journals, where they become available to other scientists. Before most journals will publish a research study, a panel of experts examines the research for originality and quality. Researchers also present the results of their work at meetings of professional societies, such as the Royal Society or the British Association for the Advancement of Science. Some scientists also write books about their studies.

Most applied researchers work for a business firm that hopes to use their research to make money from a new product. As a result, applied researchers often work in secrecy. They may conceal the results of their work permanently or until the results are protected by a patent. Findings that lead to a useful process or product become the property of the firm that sponsored the research.

How research is financed

Research requires large investments for laboratories, equipment, and researchers' salaries. Funds for these purposes come mainly from governments and business firms.

Government. Many countries provide financial support for science research through government agencies or grant-awarding bodies. The agencies themselves often carry out research as well as provide funds for other researchers.

Business firms that rely on advanced technology invest a proportion of their income in research. Most of this money is spent on applied research in industrial processes and products, but some firms spend part of their budget on basic research. Many companies have a specialized department devoted to research and development, often called simply *R and D.*

Business firms keep the details of most research secret to protect themselves from competitors. However, associations of industries that produce similar products often cooperate in planning and conducting research. This research may aim to improve products or processes or to standardize a product.

Other sources of funds for conducting and promoting research include foundations, the United Nations (UN), and professional societies of scientists. Foundations support studies conducted by universities, industrial companies, and private research organizations. The UN provides funds for research concerning food development, population control, and peaceful uses of nuclear energy. Professional societies of scientists in the same field hold international meetings at which researchers present results of their work and discuss common concerns.

Related articles in ***World Book*** include:

Types of research

Advertising (Research)
Anthropology (How anthropologists work)
Invention
Market research
Medicine (The role of medical research)
Motivation research
Psychology (Methods of psychological research)
Sociology (Methods of sociological research)
Science

Other related articles

Laboratory
Library (Research libraries)
Public opinion poll
Rand Corporation
Statistics
United Nations University

Reserpine is a drug used to treat mild *hypertension* (high blood pressure). It is obtained from a shrub called *Rauwolfia serpentina,* which grows in India and Southeast Asia. Extracts from this plant have been used for centuries in that part of the world to treat such disorders as hypertension, insomnia, mental illness, and poisoning from snakebite.

During the 1950's, doctors in Western countries began to use reserpine to treat hypertension and to calm emotionally ill patients. Since the 1960's, the drug has been used mainly to lower the blood pressure of people with mild hypertension. Other, more effective drugs have largely replaced reserpine in the treatment of emotional illness.

Reserpine may produce harmful reactions. Small doses can cause drowsiness, severe depression, and peptic ulcers. Larger doses may result in abnormally low blood pressure and loss of consciousness.

Reservoirs store vast quantities of water. This reservoir in the Elan Valley, Wales, provides water for industry and people in many British cities.

Reservation. See **Indian, American** (Indians today).

Reservoir is a place where large quantities of water are stored to be used for irrigation, power, water supply, and recreation. A reservoir may be either natural or artificial. Natural lakes form reservoirs from which many cities obtain their water supply.

Engineers can make an artificial reservoir by building a dam across a narrow valley or by digging a basin in a level tract of land. Examples of reservoirs that are made by building dams are those behind the Kariba Dam in Zimbabwe, Egypt's Aswan High Dam, and the Grand Coulee Dam in the United States. The size of a reservoir is measured in cubic metres.

A small reservoir that stores rain water for household use is called a *cistern*. It is an underground basin that may be built round or square, and any size desired. Cisterns should be lined with concrete to keep out underground water that contains organic matter, and surface water. But rain water gathers impurities as it passes through the air. Therefore, the water should pass through a *filter* (screen) to remove the impurities before entering the cistern.

Some small cities store their water in large tanks supported on a high framework or in small *holding reservoirs*. The tanks or reservoirs are built higher than the highest buildings to create enough pressure to force the water to the tops of the buildings.

See also **Aqueduct; Dam; Irrigation** (Surface water); **Water; Water power.**

Largest reservoirs in the world

Reservoir	Location	Capacity in millions of cubic metres	Year completed
Lake Victoria†	Kenya, Tanzania, Uganda	204,800	1954
Bratsk	Russia	169,000	1964
Lake Nasser	Egypt, Sudan	162,000	1970
Kariba Lake	Zambia, Zimbabwe	160,368	1959
Lake Volta	Ghana	147,960	1965
Manicouagan	Canada	141,851	1968
Guri	Venezuela	135,000	1986
Krasnoyarsk	Russia	73,300	1967
Williston Lake	Canada	70,309	1967
Zeya	Russia	68,400	1978

†Enlarged natural lake.
Source: U.S. Committee on Large Dams.

Resin is any one of a class of natural substances used in varnishes, medicines, soaps, paints, and other applications. Natural resins have largely been replaced by synthetic resins (see **Resin, Synthetic**). Natural resins may be divided into three main groups: (1) those that flow from plants as the result of wounds; (2) those extracted from wood by solvents; and (3) fossil resins found with the preserved remains of animals and plants. A scale insect of the acacia tree also produces a resin, called *lac*.

Gum resins, such as asafetida, aloe, myrrh, and the gum of the balsam tree have often been used in medicines. However, recent developments in pharmacology question the use of resins in medicine. *Rosin*, a resin obtained from several varieties of pine trees, is used in paints, varnishes, and printing inks. *Oleoresins* are resins combined with essential oils that are used in turpentine and tar.

Related articles in *World Book* include:

Amber	Gum resin	Mastic
Balm of Gilead	Lac	Rosin
Balsam		

Resin, Synthetic, is any one of a large group of chemical compounds that includes most of our common plastics. These resins may be made as fibres or films, or moulded into a great variety of shapes, ranging from pocket combs to car bumpers. Manufacturers use these compounds in paints and adhesives and as coatings for cloth, paper, and metal.

Synthetic resins are made up of many simple molecules linked together to form large, complex ones. Scientists call them *high polymers. Polymer* comes from the Greek words *poly*, meaning *many*, and *meros*, meaning *part*. The nature of synthetic resins is determined by the chemicals they contain and by the patterns of the new molecules. If long, fibrous molecules form, the substance is tough but softens when heated. If the molecules form long chains with many crosslinks, the resin is hard, brittle, and sets when it is heated. If few crosslinks form, the resin usually is elastic. Resins with short chainlike molecules have a gummy or waxlike quality.

Manufacturers use coal, petroleum, limestone, wood, salt, air, and water to make synthetic resins. Complicated chemical processes change these common materials into a variety of chemicals such as alcohol, formaldehyde, glycerol, phenol, ethylene, ammonia, and urea. These substances are then combined in many ways to form the complex molecules of the resins.

Synthetic polymers vary greatly in composition, properties, and uses. Manufacturers often alter the original properties before making them into marketable items. They do this by combining or compounding the substances with fillers, colours, lubricants, and other materials and by heat treatment.

Related articles in *World Book* include:

Bakelite	Plastics
Molecule	Polymer
Painting (Synthetic resins)	Silicone
	Urea

Resistance. See **Electric circuit** (Circuit mathematics); **Strength of materials.**

Resonance. See **Sound** (Resonance).

Resources, Natural. See **Natural resources.**

Respighi, Ottorino (1879-1936), was one of the most successful Italian composers of the early 1900's. His studies with the Russian composer Nickolai Rimsky-Korsakov were a crucial influence on his vividly colourful orchestrations. The tone poems *The Fountains of Rome* (1917) and *The Pines of Rome* (1924), his most famous compositions, also show the influence of the composers Maurice Ravel and Richard Strauss. Respighi's interest in older music is reflected in the use of medieval Gregorian themes. Respighi was born in Bologna.

Respiration is the process by which human beings and other living things obtain and use oxygen. Except for certain microorganisms, all living things require oxygen to live. Respiration also involves the elimination of carbon dioxide, a gas produced when cells use oxygen.

Respiration may be divided into three phases: (1) external respiration, (2) internal respiration, and (3) cellular respiration. In external respiration, or breathing, a plant or animal takes in oxygen from its environment and releases carbon dioxide. In internal respiration, oxygen is carried to the cells of the organism and carbon dioxide is carried away from them. In cellular respiration, oxygen is used in chemical reactions within the cells. These reactions release energy and produce carbon dioxide and water as waste products.

Organisms carry out external respiration in various ways, depending on their size and environment. For example, single-celled organisms, such as diatoms, and amoebas, exchange oxygen and carbon dioxide directly with the environment through their cell membranes. In higher plants and animals, however, each cell lacks direct contact with the environment. External respiration in these organisms requires a system of specialized structures or organs.

This article deals chiefly with respiration in human beings and other mammals. Respiration in other animals with lungs—such as birds, reptiles, and most adult amphibians—is carried out in similar ways.

External respiration

Organs of breathing. The lungs are the chief organs of breathing. They are elastic structures in the chest cavity. Each lung contains millions of small air chambers, or sacs, called *alveoli.* A network of tiny blood vessels called *capillaries* lies within the walls of each alveolus. See **Lung** (Parts of the lungs).

Other structures important in breathing are the *chest wall* and the *diaphragm.* The chest wall includes the ribs—which form a protective cage around the chest cavity—and the muscles between the ribs. The diaphragm is a dome-shaped sheet of muscle that separates the chest cavity from the abdomen.

Air enters and leaves the body through the nose and the mouth. The *pharynx* (back of the nose and mouth), the *larynx* (voice box), and the *trachea* (windpipe) are the air passages that connect the nose and mouth with the lungs.

The process of breathing. Breathing consists of two acts, *inspiration* (breathing in) and *expiration* (breathing out). During inspiration, also called *inhalation,* air from the atmosphere is drawn into the lungs. During expiration, or *exhalation,* air is expelled from the lungs.

Inspiration occurs when the diaphragm and the muscles of the chest wall contract. This action makes the chest cavity longer and wider, causing the lungs to expand. The expansion of the lungs creates a slight vacuum in the alveoli, drawing fresh air into the lungs. Oxygen makes up about 20 per cent of the volume of this fresh air. Almost all the rest of it is nitrogen. Only about 0.03 per cent is carbon dioxide.

Expiration results when the diaphragm and other muscles relax, allowing the lungs to retract. This action causes the pressure of the gas in the alveoli to become greater than the atmospheric pressure. As a result, gas flows out of the lungs. Carbon dioxide makes up about 5 per cent and oxygen about 17 per cent of this gas.

Oxygen and carbon dioxide are exchanged between the lungs and the blood through the thin walls of capillaries in the alveoli. Blood entering these capillaries is low in oxygen and high in carbon dioxide. Oxygen that has been inhaled passes into the blood, while carbon dioxide moves from the blood into the alveoli.

Between breaths, when the respiratory system is "at rest," the lungs still contain almost half the gas they can hold. This gas provides a reserve so that the exchange of oxygen and carbon dioxide can continue between breaths.

Control of breathing. Breathing is regulated by the *respiratory centre,* groups of nerve cells in the brain stem. Every few seconds, these cells send bursts of impulses to the muscles involved in inspiration. These signals determine the rate and depth of breathing. Another group of special cells, called *chemoreceptors,* sense the oxygen and carbon dioxide levels in the blood and the acidity of *cerebrospinal fluid* surrounding the brain. Slight increases or decreases in carbon dioxide cause changes in the acidity of body fluids. These changes may affect various body functions. Chemoreceptors send signals to the respiratory centre to quicken or slow the rate of breathing. In this way, they help maintain normal levels of oxygen and acidity in the body.

Internal respiration

Internal respiration refers to the process by which oxygen is transported to body tissues and carbon dioxide is carried away from them. Red blood cells play an essential role in this process. They contain *haemoglobin,* a molecule that can carry large amounts of oxygen. They also contain an enzyme called *carbonic anhydrase.* This enzyme helps change carbon dioxide into *bicarbonate ion,* a form that is easily carried in blood.

Red blood cells pick up oxygen as they pass through the lungs. The heart then pumps this oxygen-rich blood through the arteries to capillaries in the body tissues. There, oxygen is released from the haemoglobin and passes through the capillary walls to the tissue cells. At the same time, carbon dioxide produced by the tissue cells enters the blood. Carbonic anhydrase in the red blood cells helps change most of the carbon dioxide to bicarbonate ions. Most of these bicarbonate ions move out of the red blood cells and are carried in blood plasma. The rest of the carbon dioxide entering the blood becomes associated with haemoglobin molecules or stays dissolved in plasma. When the blood reaches capillaries in the alveoli, these reactions reverse and the released carbon dioxide enters the gas in the alveoli.

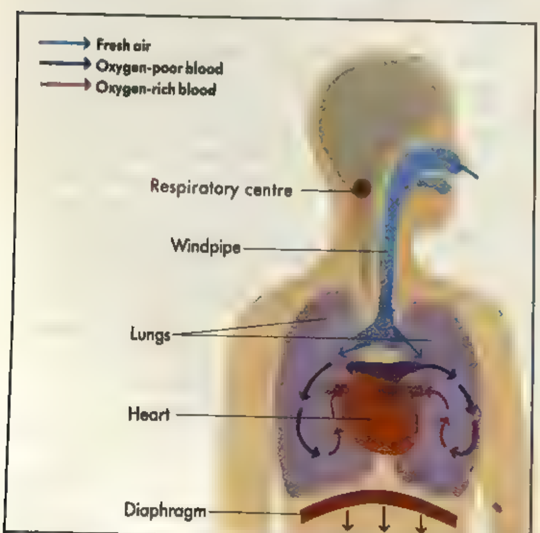
Cellular respiration

Respiration in cells involves a series of chemical reactions that occur in the presence of oxygen. These reactions release energy from food substances and make it available so that the cells can function.

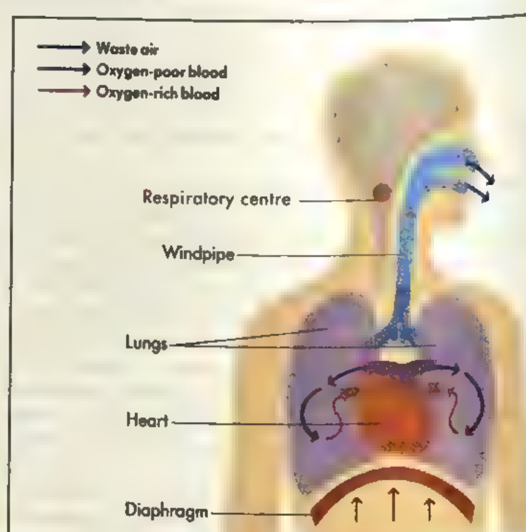
Cells can obtain some energy without oxygen by a chemical process called *glycolysis.* Glycolysis converts molecules of *glucose* (a simple sugar) into smaller molecules called *pyruvic acid.* This action releases energy, which is captured in a compound known as *adenosine triphosphate* (*ATP*). ATP is very important because it supplies energy to all cells. However, glycolysis produces only a small amount of ATP.

Cells require oxygen to obtain large amounts of ATP. When oxygen is present in a cell, pyruvic acid enters a series of chemical reactions called the *Krebs cycle* (see **Krebs cycle**). At various steps during the Krebs cycle, energy is captured and passed on to a second series of reactions called the *electron transport chain.* As a result of these reactions, carbon dioxide and water are formed and a great deal of energy is stored as ATP.

External respiration External respiration, or breathing, is the process by which the body takes in oxygen from the atmosphere and releases carbon dioxide into the atmosphere. This exchange of gases takes place in the lungs. Breathing is controlled by an area of the brain called the *respiratory centre.*



Inspiration—the act of drawing air into the lungs—occurs when the inspiratory muscles contract. Contraction of the *diaphragm,* the chief inspiratory muscle, makes the chest volume larger and thus expands the lungs. This expansion creates a slight vacuum in the lungs, and air flows in from the atmosphere.



Expiration—the act of letting gas out of the lungs—takes place when the inspiratory muscles relax. The relaxation of these muscles removes the force expanding the lungs, which become smaller. Because of the smaller lung volume, gas pressure inside the lungs increases, and gas flows out into the atmosphere.

External respiration in animals without lungs

Many animals that live in water, including fish and shellfish, have gills for exchanging oxygen and carbon dioxide with their environment. When water comes in contact with the gills, oxygen moves easily from the water and passes through the thin membrane that separates the animal's blood from the water. At the same time, carbon dioxide moves from blood to water. Fish take in water through the mouth and force it out over the gills.

Other animals that lack lungs also have special ways of breathing. For example, earthworms breathe through their skin. They have a system of capillaries just beneath the skin. Oxygen and carbon dioxide are exchanged between air in the soil and the animal's blood. Insects have a system of tiny air tubes called *tracheae* for breathing. These tubes carry air from the environment directly to different parts of the body.

Some animals, such as amphibians, use more than one organ of respiration during their life. Frogs, for example, breathe through gills while they are tadpoles. Mature frogs breathe chiefly with lungs and also exchange gas with the environment through their skin.

Respiration in plants

In higher plants, oxygen and carbon dioxide move into and out of the roots and stems through the outer layers of cells. The majority of gas exchange in plants, however, takes place through small openings in the leaves called *stomata.*

Like animal cells, plant cells obtain energy through chemical reactions that break down glucose. Green plants also produce energy through a "reverse respiration" process called *photosynthesis.* In photosynthesis, the plant uses energy from light to make glucose. During this process, the plant takes in carbon dioxide from the environment and produces oxygen as a waste product. Certain bacteria also perform photosynthesis. See **Photosynthesis.**

Related articles in *World Book* include:

Animal (How animals breathe)	Hyperventilation
Artificial respiration	Lung
Circulatory system (In respiration; diagram)	Nose (with diagram)
Diaphragm	Plant (Respiration)
Gill	Spirometer
	Trachea

Respirator. See **Ventilator.**

Respiratory distress syndrome is a lung condition that affects premature babies. Such babies are born before the end of a normal nine-month pregnancy. The disease is related to the underdevelopment of the lungs of these infants. The air sacs of the lungs collapse, causing rapid, difficult breathing and, in many cases, death by suffocation. Respiratory distress syndrome ranks as a major cause of death among premature infants. It attacks few babies born after a nine-month pregnancy.

A victim of the disease has difficulty breathing within minutes after birth. Underdeveloped lungs lack a substance called *pulmonary surfactant.* This substance prevents the air sacs from collapsing. The intensive care units in many hospitals include respirators and high-humidity incubators for treating respiratory distress syndrome victims. Such treatment keeps many babies alive long enough for their lungs to become sufficiently developed to produce pulmonary surfactant. This development takes four to five days in most cases, but it may require several weeks. Most infants who recover have no permanent aftereffects. Scientists hope to develop artificial surfactants that could be given to infants soon after birth to prevent the disease.

In the early 1970's, doctors discovered a way to determine whether an unborn baby's lungs lack pulmonary surfactant. With this knowledge, a doctor may try to delay a premature birth until the lungs have developed sufficiently. If a premature birth is not delayed, a doctor can give the mother a synthetic hormone to accelerate the lung development of the fetus.

Formerly respiratory distress syndrome was known as *hyaline membrane disease.* This was because a clear, glassy material called hyaline was found in the lungs of infants dying from the condition.

Respiratory system. See **Respiration.**

Response. See **Learning** (How we learn); **Reflex action.**

Responsible government was established in the colonies of Australia and New Zealand when they gained the right to govern themselves without interference from the British government. The British Parliament passed an Act setting up provincial governments in New Zealand in 1852. New South Wales and Victoria gained responsible government in 1855; Tasmania and South Australia, in 1856; Queensland, in 1859; and Western Australia, in 1890.

Rest. See **Health** (Rest and sleep); **Sleep.**

Rest. See **Music** (Indicating time values).

Restaurant is a business establishment that serves food and beverages to the public. The first restaurants operated along roadsides, where travellers stopped to rest and to restore their energy. The word *restaurant* comes from the Latin word *restaurare,* meaning *to restore.* Today, restaurants may be found almost everywhere—on quiet streets and busy roads; in hotels; in airports, bus stations, and railway stations; in amusement parks; in office buildings; and also in shopping centres.

Restaurants make up the largest part of the *food service* industry. All places that serve food to people away from home form part of this industry, including schools, hospitals, factories, and prisons.

Kinds of restaurants. There are two main kinds of restaurants: (1) table-service restaurants and (2) fast-service restaurants.

Table-service restaurants. Most of these establishments have a headwaiter or a hostess who seats the customers at a table and gives them a menu. A waiter or a waitress takes their order and serves their food. The most popular table-service restaurants are *family* restaurants, most of which offer several kinds of foods at moderate prices.

Other types of table-service restaurants include *ethnic* and *gourmet* restaurants. Ethnic restaurants serve the food of a certain country, such as China, India, Italy, or Mexico, or foods associated with certain peoples, for instance Jewish restaurants. Many such restaurants also provide *takeaway* food for people to eat at home. Gourmet restaurants offer unusual foods from the little-known recipes of great chefs. Most of these dishes cost

much more than the majority of foods at other kinds of restaurants.

Some table-service restaurants offer a *buffet.* The various dishes of a buffet meal are placed on a counter or table, and the customers serve themselves. A waiter or waitress may serve beverages. In some restaurants, a waiter or waitress serves the main course, and diners serve themselves salad and dessert from a buffet.

Fast-service restaurants provide inexpensive food and quick service. Many of these restaurants serve such foods as baked potatoes, hamburgers, kebabs, fried chicken, pizza, fish and chips, or sandwiches. Some food experts believe that people who frequently eat in fast-service restaurants do not have a balanced diet. But some such restaurants employ dietitians or make other efforts to ensure that their limited menu offers as much nutrition as possible. Fast-service restaurants include cafeterias, and takeaways. Self-service cafeterias display food on a counter. Customers move past the counter with a tray and serve themselves. Coffee bars and tea shops specialize in serving beverages. They also provide cakes or other light snacks. Some fast-service restaurants also provide a delivery service.

Chains and franchises. A restaurant *chain* consists of two or more restaurants owned by one person or company. Most chains are formed by a person who has succeeded with one restaurant and wishes to expand.

In most *franchise* arrangements, the owner of a famous restaurant grants another person or firm the right to own and operate a restaurant of the same name. In return for this right, called a *franchise,* the original owner receives a fee. Under most franchise agreements, the franchise buyer also pays a percentage of the restaurant's annual income to the original owner. In return, the franchise purchaser receives a number of services from the original owner, including financial advice and management training programmes. The franchise buyer also receives the right to use the original owner's patented products and trademarks. In addition, the buyer benefits from advertising conducted by the original owner.

Restaurants include table-service restaurants and fast-service restaurants that offer quick service and inexpensive food.

Restoration was the period in English history that followed the return of the House of Stuart to the throne. The Puritan leader Oliver Cromwell, who had ruled as Lord Protector, died in 1658. His son Richard, who succeeded him, was a weak ruler, and civil war threatened England. But General George Monk seized control of the government, and restored the Stuart Prince Charles to the throne. The prince had lived in exile after the execution of his father Charles I in 1649. A new Parliament, elected in 1660, abolished Cromwell's government and restored the monarchy in the name of Charles II.

The English welcomed Charles back to the throne. On his journey to London, people everywhere greeted him with wild enthusiasm. His reign was dated back to the execution of Charles I, instead of the actual year of the restoration. Parliament re-established the Anglican Church as the official church of England and returned the property that had been taken from it. Parliament also passed many laws against the Puritans. Their worship was severely restricted, and their political rights were greatly limited.

During the Restoration period, extreme reaction set in against the strict morality of the Puritans. The court of Charles II became known for immorality and loose living. People were valued not for their wisdom or integrity, but for their cleverness and wit.

The Restoration marked the return of royal power, but governmental power actually was divided between the monarch and Parliament. This division of power ended three years after Charles' death. The Glorious Revolution of 1688 sharply limited the king's power and gave Parliament greater power.

See also **Charles (II)** of England; **Cromwell, Oliver; England** (History: The Restoration); **English literature** (Restoration literature); **Monk, George.**

Restoration drama. See **English literature** (Restoration drama).

Restormel (pop. 88,300) is a local government district in the English county of Cornwall. It extends from the Atlantic coast in the north to the English Channel in the south. Tourism and extracting china clay are the two main industries. The main tourist centre is Newquay on the north coast. Mevagissey and Fowey are resorts on the south coast. The district's administrative centre is St Austell. See also **Cornwall.**

Boating for pleasure, or to catch fish, is important to the economy of Restormel, where thousands of tourists sail each year.

Resurrection is a religious belief that a dead person will return to life through the power of God. The person will be restored to life in his or her physical body and individuality, but in perfected form. Most believers expect resurrection to occur at the end of time and be accompanied by God judging people based on the good and evil of their lives.

The belief in resurrection is important in Judaism, Christianity, and Islam. The first references in Jewish literature to the resurrection of individuals at the end of time appear in the Book of Daniel (probably composed in the 160's B.C.). Belief in final resurrection and judgment is also a major doctrine in Islam.

In Christianity, the resurrection of believers to eternal life at the Last Judgment is linked to the Resurrection of Jesus. Christians have traditionally believed that God defeated death through Jesus' Crucifixion and Resurrection. The story of Jesus' Resurrection is told in all four Gospels. Saint Paul discusses the resurrection of believers in I Corinthians 15. Resurrection is a topic of sermons in the Acts of the Apostles. During the first 300 years of Christianity, Easter Sunday gradually developed as a major celebration of Jesus' return to life.

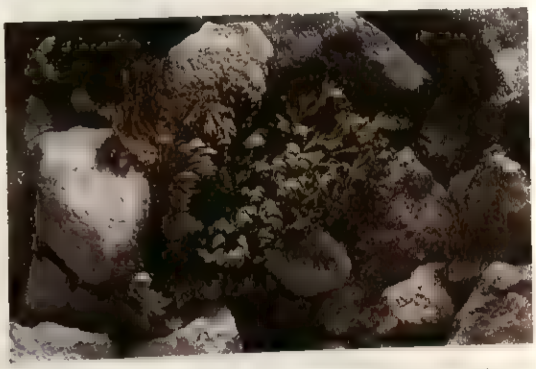
See also **Easter; Jesus Christ** (The Resurrection); **Mormons** (Church doctrines); **Islam** (Life and death).

The Resurrection (about 1597-1604), an oil painting on canvas; The Prado, Madrid

The Resurrection of Jesus Christ is a central doctrine of Christianity. The artist El Greco painted a Resurrection scene of a serene Jesus rising above figures overcome by awe and fear.

Resurrection plant is the name of several different plants that can be dried, but turn green again when they are watered. The dried stems curl into a tight ball. But they spread out when the plant is put into water. A common plant of this type, called the *rose of Jericho,* belongs to the mustard family. It grows from seeds and is native to northern Africa and many regions of the Middle East. The mature plant loses its leaves, curls up into a ball with its seed pods inside, and blows across the land. Another resurrection plant, also called *rose of Jericho,* is in the selaginella family. It reproduces by means of microscopic cells called *spores.*

Scientific classification. The rose of Jericho of the mustard family, Cruciferae (Brassicaceae), is *Anastatica hierochuntica.* The rose of Jericho of the selaginella family, Selaginellaceae, is *Selaginella lepidophylla.*



A resurrection plant becomes green again after a rain, *above.* Without moisture, the plant curls up into a dry ball.

Resuscitator. See Ventilator.

Reszke is the family name of two brothers who became famous opera singers. Both were born in Warsaw, Poland.

Jean de Reszke (1850-1925) was an operatic tenor. His first teacher was his mother. Later, he studied with Italian teachers. He made his operatic debut as a baritone at Venice in 1874. But it soon became obvious to him that baritone roles did not suit his voice. De Reszke's first appearance as a tenor started him on a brilliant career. He was in constant demand in Europe. Later, he also sang in New York City with the Metropolitan Opera Company. Perhaps de Reszke's greatest role was Tristan in Wagner's *Tristan and Isolde.* After de Reszke retired from the stage, he taught in France.

Edouard de Reszke (1853-1917) was a celebrated operatic bass. He trained largely in Italy, and made his debut in 1876 in Paris as the king in Verdi's *Aïda*. Verdi himself conducted the performance. From 1891 to 1902, de Reszke sang with the Metropolitan Opera Company in New York. He sang lyric, dramatic, and comic roles with ease. He spent his last years in Poland in poverty.

Retailing consists of all the activities that result in the offering for sale of merchandise or services to consumers for their own use. Retailing is the final step in bringing goods to consumers. Not all retailers sell merchandise. For instance, a shop that rents tools for home use sells the service of having tools available. It does not sell the tools themselves. Many retailers sell both goods and services. A carpet store, for example, may fit the carpets as well as sell them. Retailers sell to consumers for use, rather than to producers or other firms for resale. When a motor manufacturer needs tyres for the cars it builds, it does not buy from a retailer. But individuals who need tyres for their own cars purchase them from a retail tyre dealer. Some retailers do not operate from a store. Instead, they sell goods from a market stall or a kiosk.

Retailers perform several functions as part of the marketing system. They assume risk by buying merchandise without any guarantee that they will be able to sell it and by extending credit to consumers who purchase their goods. Retailers bring buyers and merchandise together by purchasing products in large lots and dividing them up for sale in smaller quantities that are more convenient for consumers. Retailers stock a variety of goods to provide customers with a wide range of choice and quick delivery. Through advertising and other types of promotion, retailers help attract consumers to a producer's goods. In addition, because of their day-to-day contact with customers, retailers are in a good position to know what consumers want. They can therefore provide producers with useful information on consumers' buying habits.

The retail sector is extremely important in every country of the world and is a major employer. Retail firms can be classified according to the products they sell and in a number of other ways. Some stores are located in central areas, but others are in shopping centres or malls. Some are owned by individual proprietors, and others are part of large, national, or even international, chains. Some retail businesses are organized as cooperatives and are owned by the people who use their services (see **Cooperative**). This article discusses (1) speciality stores, (2) department stores, (3) supermarkets, (4) chain stores, (5) nonstore retailing, and (6) mobile shops.

Speciality stores normally sell a single type of merchandise, such as clothing, books, records, or jewellery. They may also carry a limited number of closely related lines of merchandise.

Department stores have separate departments devoted to selling a particular line of goods. Such *hard goods* as furniture and appliances are sold in one section of the store, and such *soft goods* as clothes and sheets are sold in other areas. Many department stores also have separate areas that provide such services as gift wrapping and credit. See **Department store**.

Supermarkets are large retail food stores that account for a large proportion of food sales in industrialized countries. Supermarkets began operating throughout the United States during the 1930's. At first, they sold only food. Today, however, supermarkets sell many other products as well. See **Supermarket**.

Chain stores are groups of two or more stores whose activities are coordinated by a common, central management. In some chains, all the stores are owned by a single company. In others, each store is owned by an individual proprietor who pays a fee for the franchise (see **Franchise**). Today, many department stores, shoe shops, chemists, and supermarkets are parts of chains. See **Chain store**.

Nonstore retailing is selling that does not take place in a store building. It includes such methods as selling by mail order, vending machine, telephone, and door-to-door visits. See **Mail-order business; Vending machine**.

Retailers may operate from a large store, or sell goods from a market stall like the one on the left.

Mobile shops are another important retail outlet. They are used for selling goods that are in constant demand, such as groceries, fish, and meat. They usually operate in rural areas and are useful in areas where there are elderly people unable to get about easily.

See also **Salesmanship; Sears, Roebuck and Company.**

Retainer is a formal agreement between a lawyer and a client in which the lawyer agrees to take the client's case. This type of agreement is called a *special* retainer. There is also a *general* retainer, in which the lawyer agrees to act for the client when needed. Usually, a client retains a lawyer by paying a *retaining fee,* which may also be called a retainer. After a lawyer has accepted a retaining fee from a client, the lawyer is legally bound to represent that client in the case. The lawyer cannot take a retaining fee from the other party to the case. A lawyer who accepts a general retainer cannot perform services for anyone else that would be against the client's best interests.

Retardation. See **Mental retardation.**

Retief, Piet (1780-1838), was a South African Boer leader. In 1837, he published a *manifesto* (public declaration of policy) in the Grahamstown *Journal.* It listed the grievances of the *Boers* (Dutch farmers) and explained why they were leaving the Cape Colony forever on a trek northward (see **Great Trek**).

Retief was born in the Cape Colony. He had little formal education. Originally a wealthy landowner, he was later plagued by debt and worked as a baker, miller, merchant, timber contractor, and farmer. During a brief period as "governor" of the Emigrant Boers beyond the Cape Colony's borders, Retief led a party of Boer families and their servants across the Drakensberg Mountains into Natal. In 1837 and 1838 Retief tried to negotiate with Dingane, the Zulu king, for a grant of land. Dingane feared Boer invasion and executed Retief and his men in February 1838.

Retina. See **Eye.**

Retinoblastoma. See **Blindness** (Diseases); **Cancer** (Inherited tendencies).

Retinol. See **Vitamin** (Vitamin A).

Retirement pension. See **Pension.**

Retrieval system. See **Information retrieval.**

Retriever is a hunting dog trained to *retrieve* (find and bring back) game that has been shot. The dog has a coat of *guard hairs* (outer hairs), and an undercoat that protects it from water and cold. It is a strong swimmer and has a fine sense of smell. It takes training easily. Dog breeders generally classify retrievers as sporting gundogs. The five recognized breeds of retrievers are the *Chesapeake Bay,* the *curly-coated,* the *flat-coated,* the *golden,* and the *Labrador.*

See also **Dog** (pictures).

Retrolental fibroplasia. See **Eye** (Diseases of the retina).

Retting. See **Flax** (Growing and processing fibre flax); **Hemp; Jute.**

Returned Services League of Australia, popularly known as the *R.S.L.,* is an organization primarily concerned with the welfare of its members and other former servicemen and servicewomen and their dependents. It has about 270,000 members. It was first formed as a national organization on June 6, 1916.

Reunion is an island in the Indian Ocean, about 640 kilometres east of Madagascar. For location, see **Indian Ocean** (map). Of volcanic origin, it covers 2,512 square kilometres. Saint-Denis (pop. 109,072) is the capital.

Reunion's important products are vanilla, tobacco, tea, sugar cane, perfumes, and maize. The population of 564,000 consists largely of French Creoles, with some Indians and Chinese. Discovered by the Portuguese in the early 1500's, it was not settled until the French took possession in 1642. They named it *Bourbon.* The island received its present name in 1848. Since 1946, it has been an overseas department of France. Reunion is governed by a 36-member council that is elected by the people.

Reuter, Baron de (1816-1899), founded Reuters, one of the world's leading news services. Reuters was one of the first news services to furnish financial, political, and general news to European newspapers. In 1849, Reuter began a service using pigeons to carry news between the terminal points of telegraph lines at the borders of Germany, Belgium, and France. He later settled in London and established Reuters in 1851 to relay European financial news. He entered the general news business in 1858. Reuter started a cooperative effort among several news agencies that expanded the worldwide distribution of news. He directed the operations of Reuters until his retirement in 1878 and worked as an adviser to the agency until his death. Reuter's full name was Paul Julius Reuter. He was also called Baron Von Reuter. He was born in Kassel, Germany. See also **Reuters.**

Reuters is one of the world's largest news-gathering agencies. It serves more than 150 countries and has bureaus in about 100 nations. Reuters also provides financial information to banks, brokers, and corporations. Controlling interest in the service is held by newspapers from a number of nations, including Great Britain, Ireland, Australia, and New Zealand.

Reuters was founded in London in 1851 by Baron de Reuter, a German journalist (see **Reuter, Baron de**). It started as a financial service and expanded in 1858 to furnish general news as well.

Revelation, Book of, is the last book of the New Testament of the Bible. It is also known as the *Apocalypse,* from a Greek word that is translated as *revelation.* The book was written by a man named John while he was in exile on the island of Patmos in the Aegean Sea, probably about A.D. 95. Many scholars believe that this was not the apostle John, but another person of that name.

The Book of Revelation is an example of a special type of literature known as *apocalyptic literature.* The only other example of this type of literature in the Bible is the Book of Daniel. Like other apocalyptic literature, Revelation is addressed to people undergoing persecution. It encourages them to stand firm, principally by predicting the rapidly approaching end of the world, when God will rescue them by destroying the powers of evil. The author presented this prediction in symbolic language. To the original readers of the book, the meaning of these symbols was clear. To modern readers the symbols seem obscure, and close study is required to understand the original meaning of the book.

See also **Four Horsemen of the Apocalypse; Bible** (Books of the New Testament).

Revenue, Inland. See **Inland revenue.**

Oil painting on canvas by John Singleton Copley (about 1768); Museum of Fine Arts, Boston, Massachusetts, U.S.A.

Paul Revere was a noted American craftsman who won fame for his patriotic activities during the American Revolution.

Revere, Paul (1735-1818), was an American patriot who, in April 1775, carried news to the people of Lexington, Massachusetts, of the approach of the British. He warned the leaders Samuel Adams and John Hancock of their danger, and called the citizens of the countryside to arms. His exploit inspired Henry Wadsworth Longfellow's "Paul Revere's Ride," one of the most popular poems in American literature. Revere made other contributions during the American Revolution and aided the nation's industrial growth.

His early life. Paul Revere was born on Jan. 1, 1735, in Boston, Massachusetts, the son of a silversmith. His family was of French Huguenot descent, and Paul's father changed the family name from Rivoire "merely on account that the Bumpkins should pronounce it easier." Paul studied at North Grammar School in Boston, and learned the silversmith's trade. In 1756, he served for a short time in the French and Indian War. Then he married Sarah Orne and entered his father's silversmith business. He soon became interested in supporting American liberty. Revere also served as a special messenger for the Boston patriots. He was so familiar to the British in this role that his name appeared in London journals.

Paul Revere's ride. In 1775, King George III instructed General Thomas Gage, the British commander in chief in Massachusetts, to enforce order among the rebellious colonists. Gage ordered Lieutenant Colonel Francis Smith to Concord with a detachment of 700 men. Smith and his soldiers were given instructions to destroy the supplies there and to arrest Adams and Hancock for treason.

Smith assembled his force on Boston Common on the evening of April 18. His orders were secret, but the patriots had learned about them. Joseph Warren, a patriot leader, sent Revere and William Dawes to warn Adams and Hancock in Lexington and the patriots in Concord. They arranged for a signal to be flashed from the steeple of the Old North Church in Boston. Two lanterns would mean that the British were coming by water, and one, by land. Contrary to Longfellow's account, the signal was not sent to Revere. Instead, Revere directed that the signal be sent to friends.

Revere left Boston at about 10 p.m., and arrived in Lexington at midnight, riding a borrowed horse. At 1 a.m., Revere, William Dawes, and Dr. Samuel Prescott left for Concord. A British cavalry patrol surprised them on their way. Prescott and Dawes escaped, but Revere was captured. Only Prescott got through to Concord. The British released Revere and let him return to Lexington without his horse. There he joined Adams and Hancock, and they fled to safety in Burlington. But Revere returned to Lexington to rescue valuable papers in Hancock's trunk. When the British arrived in Lexington on April 19, they found the militia waiting.

Craftsman and industrialist. During and after the war, Revere continued his silversmith trade in Boston. Craftworkers still copy the graceful lines of his work.

Revere was the first American to discover the process of rolling sheet copper, and he built the first copper-rolling mill in the United States. Before that time, all sheet copper had to be imported.

Reversion. See Atavism.

Reviewing. See Criticism.

Revival of learning. See Humanism; Renaissance.

Revivalism is an approach to religion that emphasizes individual religious experience rather than doctrines. It is often associated with fervent, emotional preaching.

Periods of Christian revivalism occurred in Europe among German Pietists and English Methodists during the 1700's. In the United States the first major revival movement was the Great Awakening, which began in the 1730's. This movement was the first of many revivalist "Awakenings," usually associated with frontier camp meetings and outdoor religious services. During the mid-1800's, the Baptists and Methodists were the chief denominations that used revivalistic methods. Their meetings were very popular among the working people of the time.

During the late 1800's and early 1900's, many preachers brought revivalism to the growing cities of the Industrial Revolution. In the late 1900's, the revivalist tradition has been carried on worldwide by such preachers as Billy Graham.

See also **Graham, Billy.**

Revolution is a term that generally refers to a fundamental change in the character of a nation's government. Such a change may or may not be violent. Revolutions may also occur in other areas, including cultural, economic, and social activities. People who work to replace an old system with a new one are called revolutionaries.

Kinds of revolution. A political revolution may change various ways of life in a country, or it may have no effect outside the government. For example, the Russian Revolution of 1917 not only deposed the czar but also began major social changes, such as the elimination of private property. On the other hand, the Ameri-

can Revolution (1775-1783) changed a political system without causing basic social changes.

Some revolutions last for many years. The Chinese Communists fought for 22 years before defeating the Nationalist Chinese government in 1949. This revolution involved widespread guerrilla warfare, a popular form of combat among modern revolutionaries. See **China** (History); **Guerrilla warfare.**

Some political movements that appear to be revolutions do no more than change a country's rulers. Many Latin-American political uprisings have replaced dictators without making fundamental changes in governmental systems. Political scientists call such movements *rebellions* rather than revolutions. However, a rebellion sometimes leads to a political or social revolution. See **Coup d'état; Junta.**

Many revolutions involve illegal uprisings, but some occur after a legal transfer of power within the existing system. For example, Adolf Hitler took power as dictator of Germany soon after the country's president had appointed him chancellor.

Some of history's most widespread revolutions did not have political beginnings. The Industrial Revolution of the 1700's and early 1800's changed the basic nature of Western society from rural to urban (see **Industrial Revolution**). The invention of the telephone, and other advances in technology and communications during the late 1800's and the 1900's, have also caused revolutions in industry and everyday life.

Causes of revolution. Most revolutions occur because serious problems have caused widespread dissatisfaction with an existing system. Poverty and injustice under cruel, corrupt, or incapable rulers may contribute to revolution. But in most cases, social problems alone do not cause revolutions. They lead to despair rather than a willingness to fight for something better. Revolutions need strong leaders who can use unsatisfactory conditions to unite people under a programme that promises improvements.

Many revolutions occur after rulers begin to lose confidence in themselves and yield to various demands from their rivals. Such compromises by rulers, or rapidly improving social conditions, create a *revolution of rising expectations* as people begin to see hope for a better life. If changes do not keep pace with their expectations, the people lose faith in their rulers and start listening to revolutionary leaders. The French Revolution of 1789 and the Russian Revolution both began after the rulers agreed to the people's demands for representative assemblies. The Hungarian Revolution of 1956 occurred after the government released some of its strongest opponents from prison.

Not all revolutions have led to improved conditions. Some revolutionaries have worked for change only to gain political power for themselves. A number of conservative rulers have called themselves revolutionaries simply to convince the public that they support social and economic changes.

See also **French Revolution; Revolution of 1848; American Revolution; Union of Soviet Socialist Republics** (History); **Terrorism.**

Revolution of 1848 involved a series of uprisings in France, Germany, and the Austrian Empire, including parts of Italy. Causes of the revolution included demands for constitutional government; increasing nationalism among Germans, Italians, Hungarians, and Czechs; and peasant opposition to the manorial system in parts of Germany and in the Austrian Empire (see **Manorialism**).

The revolution began in France in February 1848 as a protest against voting restrictions, political corruption, and poor economic conditions. Soon afterward, the French king, Louis Philippe, abdicated. Liberal politicians then set up a new government called the Second Republic.

The revolution quickly spread to the Austrian Empire and Germany. In the Austrian Empire, students and workers rioted in Vienna. Elsewhere in the empire, Hungarian and Czech nationalists rebelled against Austrian authority. In addition, Italians tried to drive their Austrian rulers from northern Italy. In Germany, liberal uprisings swept through the German Confederation, which consisted of Prussia and 38 other independent states. Workers in German cities demanded social reform. Representatives of various parts of Germany assembled in Frankfurt to try to unify the separate states into a single nation.

The Revolution of 1848 quickly failed. In France, Louis Napoleon Bonaparte, who had been elected president, declared himself emperor. Protests by French workers were brutally put down. In the Austrian Empire, troops crushed the nationalist uprisings and defeated the Italian rebels. In Germany, monarchies became more firmly established in the major German states. In addition, the assembly at Frankfurt broke up without achieving German unity.

However, one major goal of the revolution was achieved—the ending of the manorial system in Germany and the Austrian Empire. Also as a result of the revolution, European rulers became more sensitive to the demands of nationalists and began experimenting with more liberal forms of government.

See also **Austria** (Metternich and revolution); **France** (The revolutions of 1830 and 1848); **Germany** (The Revolution of 1848); **Italy** (Italy united).

Rex cat. See **Cat** (Short-haired breeds; picture).

Rexroth, Kenneth (1905-1982), was an American poet. For much of his life, he called for freedom from traditional styles in poetry, which he considered artificial. This attitude led many critics to call Rexroth the forerunner of the *beat* movement of the 1950's. Beat writers attacked the use of what they considered outmoded traditions in art.

Rexroth's poems generally show he had a more complex, interesting, and informed mind than most Beat writers. *The Dragon and the Unicorn* (1952) is a book-length story poem that explores the nature of love. *In Defence of the Earth* (1956) contains love poetry, poems directed toward young people, and translations of Japanese poetry. Rexroth was a painter and essayist and also translated Chinese, Greek, and Latin poetry. *The World Outside the Window: The Selected Essays of Kenneth Rexroth* was published in 1987, after his death. He was born in South Bend, Indiana.

Reye's syndrome is a rare childhood disease of the liver and central nervous system. Advanced cases can result in brain damage or death. The disease kills about 10-40 per cent of its victims.

Most patients with Reye's syndrome are from 4 to 15 years old. The majority of them develop the disease while recovering from a mild viral illness, such as chickenpox or influenza. For some unknown reason, the virus apparently triggers Reye's syndrome. Studies indicate that many victims of Reye's syndrome had been given aspirin during the viral illness.

The first symptom of Reye's syndrome is repeated vomiting. In mild cases, the victim recovers with no after effects. But if the disease progresses, the child may experience convulsions and alternate between excitation and confused sleepiness. In the final stages of the disease, brain cells swell and pressure builds in the skull. The victim falls into a deep coma and may suffer irreversible brain damage or death.

The cause of Reye's syndrome has not been determined. Doctors treat the disease by giving the patient glucose and other nutrients, and by reducing the body's production of ammonia. They use drugs or surgery to lower the pressure within the skull if it reaches dangerous levels. This treatment has saved many patients. Reye's syndrome was first described by R. D. K. Reye, an Australian pathologist, in 1963.

Reykjavík (pop. 99,623; met. area pop. 145,098) is the capital and largest city of Iceland. It is a seaport on the southwest coast, at the head of Faxaflói, a bay (see **Iceland** [map]). The city is Iceland's trading centre and its centre of government and education. It has many schools, a university, an observatory, a theatre, a national museum, and a national library.

Water from nearby hot springs is used to heat all buildings in Reykjavík. The water is first piped to large concrete tanks on a hill outside the city. It is then piped into the buildings by flow of gravity.

Iceland's principal airport and a North Atlantic Treaty Organization (NATO) base are located in nearby Keflavík.

See also **Iceland** (pictures).

Reykjavík is the capital and largest city of Iceland. Rugged land lies beyond a residential area of the city.

Reynolds, Albert (1932-), an Irish Fianna Fáil politician, was *taoiseach* (prime minister) of the Republic of Ireland from 1992 to 1994. In February 1992, Reynolds was elected party leader, and became taoiseach. Reynolds was reelected taoiseach on Jan. 12, 1993, despite his party suffering a substantial drop in support in the general election held on Nov. 25, 1992. Reynolds resigned in 1994 after appointing Harry Whelehan president of the High Court, against the wishes of Dick Spring, leader of the Labour Party and deputy prime minister in the coalition government. As prime minister, Reynolds played a leading role in the peace process in Ireland, in which the Irish and United Kingdom governments worked to promote peace in Northern Ireland.

Reynolds was born at Rooskey, in Roscommon, and educated at Summerhill College, in Sligo. He spent the early part of his career in business and was a latecomer to politics. In 1975, he won election to Longford County Council and first gained a seat in *Dáil Éireann* (the lower house of the Irish Parliament) in 1977. He rose quickly to ministerial rank and became minister of posts and telegraphs in 1979. He was minister for industry and energy from March to December 1982. When Fianna Fáil returned to power in 1987, Charles Haughey appointed Reynolds minister for industry and commerce, promoting him in 1988 to minister for finance.

Albert Reynolds

Reynolds, Sir Joshua (1723- 1792), was a great English portrait painter. Reynolds' portraits show his skill in capturing the likeness of his subjects, as well as his keen understanding of human nature. Among Reynolds's masterpieces are the portraits *Hon. Augustus Keppel* (1754), *William Robertsen* (1772), and *Sarah Siddons as the Tragic Muse* (1784). Reynolds wrote 15 essays on art education called *Discourses* that stressed the importance of grandeur in art and the need for rigid academic training.

Reynolds became the most fashionable painter of his time. His close friends included James Boswell, Edmund Burke, Samuel Johnson, and other leading intellectual figures of the late 1700's. Reynolds helped found the Royal Academy of Arts in 1768, when he became its first president and was knighted. In 1784, he was appointed painter to the king.

Reynolds was born in Plympton-Earl's, near Plymouth, Devon. In 1740, he was apprenticed to Thomas Hudson, a leading London portrait painter. Reynolds later studied the works of Anton Van Dyck, the most famous portrait painter of the 1600's. In 1749, Reynolds travelled to Italy. During his stay in Italy he was influenced by paintings of such Renaissance artists as Tintoretto, Titian, and Paolo Veronese.

Reynolds returned to England in 1753. He soon became a favourite portrait painter of the wealthy and the leaders of society. He also painted charming and sensitive portraits of children. In 1781, Reynolds visited Flan-

Oil painting on canvas (1788); Tate Gallery, London

Reynolds' *The Age of Innocence* shows the artist's skill in painting sensitive and appealing portraits of young children.

ders and the Netherlands where he was influenced by the rich colours of the Flemish artist Peter Paul Rubens.

For other examples of Reynolds' paintings, see the pictures with **Blackstone, Sir William; Boswell, James; Johnson, Samuel.**

Reza Shah Pahlavi (1878-1944) ruled Persia, which he renamed Iran, from 1925 to 1941. His main goals as *shah* (king) were to make his nation self-reliant and respected, as well as to unify and modernize it. He built railways and factories, promoted education, increased job and educational opportunities for women, and reformed the legal system.

Reza was born in Alasht, a village northeast of Teheran, Iran's capital. His original name was Reza Khan, also spelled *Riza Khan.* He enlisted in the armed forces, rose through the ranks, and eventually commanded the principal military unit of Iran. In 1921, he led his troops into Teheran and overthrew the government. He became prime minister in 1923 and forced the shah, Ahmad Shah, to give up the throne. In 1925, Reza became shah and changed his family name to Pahlavi, also spelled *Pahlevi.* He named his oldest son, Mohammad Reza Pahlavi, crown prince. During World War II (1939-1945), Allied troops wanted to use Iran as a supply route. However, Reza Shah refused to cooperate. As a result, British and Soviet troops invaded the country and forced him to resign. He died in exile in South Africa and was succeeded by his oldest son.

See also **Iran** (History).

Rh factor is a substance in the red blood cells of most people. Red blood cells that contain the Rh factor *agglutinate* (clump) if they come into contact with an antibody called *anti-Rh.* This reaction can produce serious illness or death. People who have the Rh factor are known as Rh-positive. Those lacking it are Rh-negative. Karl Landsteiner, Philip Levine, and Alexander Wiener, discovered the factor in rhesus monkeys in 1940. They named it *Rh* after the monkey.

Anti-Rh does not occur naturally in the blood. But if a Rh-negative person receives a transfusion of Rh-positive blood, anti-Rh may build up in the blood plasma. By the time the antibody has been produced, the donor blood usually is so diluted that no serious reactions take place. But if the patient receives later transfusions of Rh-positive blood, the anti-Rh will attack the Rh-positive red blood cells and cause agglutination.

The Rh factor is inherited. The child of an Rh-negative mother and an Rh-positive father may be Rh-positive. Before birth, some of the baby's blood cells may enter the mother's blood. Then the mother may build up anti-Rh. Most of the antibody does not form until after the baby is born, however, so it seldom causes any problems with the first child. But if the mother becomes pregnant with another Rh-positive baby, she now has a ready-made supply of anti-Rh. The flow of large amounts of her anti-Rh into the child's blood can cause clumping and destruction of the infant's red blood cells. This condition is called *erythroblastosis fetalis, Rh disease,* or *haemolytic disease of the newborn.* Rh disease can result in severe anaemia, brain damage, and even death. But doctors can usually prevent Rh disease by injecting the mother with a serum shortly after she gives birth to an Rh-positive child. When Rh disease does occur, doctors treat the condition by giving the baby transfusions of red blood cells. Or doctors may replace the baby's blood with fresh blood.

See also **Blood transfusion.**

Rhea is a large South American bird that cannot fly. It looks like a small ostrich, and it is often called the *South American ostrich.* However, it has three toes on each

The rhea, a bird that cannot fly, resembles a small ostrich. Rheas live on the grasslands of South America.

foot, while the ostrich has two. The rhea also has larger wings and more feathers on its neck and head than the ostrich (see **Ostrich**). The common rhea stands about 1.5 metres tall and weighs about 25 kilograms.

Rheas live on the *pampas* (grasslands) of southern Brazil, Uruguay, Paraguay, and Argentina. They usually live in flocks of from 5 to 30 birds, generally in scrubland near water where they can bathe and swim. They eat leaves, roots, and insects.

Rheas have unusual nesting habits. The male scrapes a shallow hole in the ground and lines it with dry grass. Then he leads several hens to the nest, and each hen lays an egg. This process may be repeated several times, and a nest may contain up to 30 eggs. The male rhea sits on the eggs until they hatch. He also cares for the young birds.

Scientific classification. Rheas belong to the order Rheaformes. Two species make up the rhea family, Rheidae. The common, larger species is *Rhea americana.*

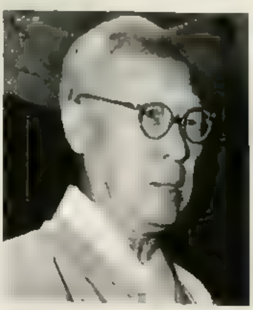
Rhea, in Greek mythology, was the wife and sister of Cronus, ruler of the race of gods and goddesses called *Titans.* Her mother was Gaea, the earth, and her father was Uranus, the sky. She became queen of the gods when Cronus overthrew Uranus. In many parts of Asia, Rhea was known as Cybele.

According to myth, Rhea and Cronus had six children—the goddesses Demeter, Hera, and Hestia; and the gods Hades, Poseidon, and Zeus. Cronus swallowed five of the children when they were born to prevent them from deposing him. However, Rhea deceived Cronus by tricking him into swallowing a stone wrapped in baby clothes in place of their youngest child, Zeus. Rhea then hid Zeus in a cave on the island of Crete. After Zeus was grown, he returned and tricked Cronus into vomiting up his other children. They helped Zeus defeat Cronus and the other Titans in a 10-year battle called the *Titanomachy.*

See also **Mythology** (Greek mythology); **Titans.**

Rhea Silvia. See **Romulus and Remus.**

Rhee, Syngman (1875-1965), a Korean statesman, became the first president of the Republic of Korea in 1948. He resigned from the presidency in 1960, soon after his election to a fourth term of office, because of widespread riots following unfair election practices.



Syngman Rhee

Rhee was born in Hwanghae province, and was educated in Seoul. Imprisoned from 1897 to 1904 for leading student demonstrations, he wrote the book *Spirit of Independence* (1904). He then studied in the United States at George Washington, Harvard, and Princeton universities. Rhee lived in exile in Honolulu for 20 years. He returned to Korea after Japan surrendered in World War II (1939-1945), but went back to Hawaii following his resignation.

Rhenium is a chemical element with the symbol Re. It is a rare, costly, silvery-white metal. It is found in small amounts in such minerals as *gadolinite,* and *molybdenite.* Rhenium has one of the highest melting points of the chemical elements. Because it withstands high temperatures, rhenium is a valuable ingredient in certain *alloys* (mixtures of metals). It is sometimes mixed with tungsten or platinum to make heat-resistant electrical equipment. It is also used in making *filaments* (fine wires) for instruments called mass spectrometers, which are used to measure the mass of charged atoms and molecules.

The German scientists Walter Noddack, Ida Tacke, and Otto Berg discovered rhenium in 1925. Its atomic number is 75, and its atomic weight is 186.207. Rhenium melts at 3180° C and boils at 5627° C.

Rheostat is a device that increases or decreases the amount of resistance in an electric circuit. By altering the amount of resistance, the rheostat regulates the flow of current through a circuit. Many different kinds of rheostats are used with electric motors, radio transmitters, generators, and other types of electrical equipment.

A simple rheostat consists of a metal resistance wire wound around a cylindrical piece of insulating material. A metal arm that can be moved along the turns of the resistance wire touches each turn as it moves. The current passes through the resistance wire and then into the movable arm. The more turns of wire on the rheostat, the greater its resistance will be, and the smaller the amount of current that will flow through the circuit it controls.

Rhesus monkey is a monkey noted for its usefulness in medical and behavioural research. It is also one of the most popular monkeys exhibited in zoos. Research on the rhesus monkey led to the discovery of the *Rh factor,* a substance in the red blood cells of most human beings (see **Rh factor**). Scientists named the substance after the animal.

The rhesus monkey lives in many regions of southern

Rhesus monkeys are among the most popular monkeys exhibited in zoos. These monkeys also serve a valuable purpose as research animals in scientific experiments.

and southeastern Asia, from Afghanistan in the west to Thailand and southern China in the east. It measures from 50 to 65 centimetres long, not including an 18- to 30-centimetre tail. Rhesus monkeys weigh from 4 to 10 kilograms and have dull yellow to brown fur. They live both on the ground and in trees in groups of about 5 to more than 100 animals. Rhesus monkeys inhabit a variety of surroundings, including deserts, farm areas, forests, mountains, and swamps. They also live in villages and bazaars of large cities. Their food includes buds, fruit, insects, leaves, roots, and various crops.

Many Hindus once regarded rhesus monkeys as sacred. But religious tolerance of the animals has declined because rhesus monkeys destroy crops and other property. Many scientists have called for conservation efforts to protect rhesus monkeys. Large numbers have been trapped for use in research and in zoos, and people are occupying land once inhabited by the monkeys.

Scientific classification. Rhesus monkeys belong to the Old World monkey family, Cercopithecidae. They are *Macaca mulatta.*

See also Macaque; Monkey (picture).

Rhetoric. See Oratory.

Rheumatic fever, is a disease that occurs primarily in children from 5 to 15 years old. It also strikes younger children and adults. Rheumatic fever gets its name from its most common symptoms—*rheumatism* (inflammation of the joints) and fever. The disease may last several weeks or months. Rheumatic fever can cause permanent damage to the valves of the heart.

Rheumatic fever is caused by bacteria called *streptococci.* People who develop the disease have had a recent streptococcal infection, such as pharyngitis. The streptococci subsequently trigger the immune system to attack the body's own tissues.

Before antibiotic drugs were developed in the mid-1900's, rheumatic fever with its resulting valve damage was a leading cause of heart disease. Today, prompt treatment of streptococcal infections with antibiotics usually prevents rheumatic fever, and it has become rare in industrial countries. However, rheumatic fever remains a problem in many developing nations.

The first symptoms of rheumatic fever usually occur a few weeks after the streptococcal infection. Common symptoms include fever, with pain and swelling in such joints as the elbows, wrists, knees, or ankles. *Nodules* (lumps) may develop under the skin over bony areas and a mild rash sometimes occurs. Some patients develop *chorea,* a condition marked by jerky, involuntary movements (see **Chorea**).

Mild to severe *carditis* (inflammation of the heart) occurs in many cases of rheumatic fever. Severe carditis can lead to heart failure. Both mild and severe carditis can cause permanent damage to the heart valves, resulting in the condition called *rheumatic heart disease.* In rheumatic heart disease, the damaged valves no longer open and close properly, and the resulting turbulent passage of blood produces a sound called a heart murmur (see **Heart murmur**). Severe rheumatic heart disease can lead to heart failure.

See also Heart (Valvular disease).

Rheumatism is a general term for disorders involving stiffness or pain in the muscles or joints. Doctors do not use the term. They refer to the disorders by more specific names. Common conditions that are frequently called rheumatism include *arthritis, bursitis, myalgia,* and *tendinitis.*

See also **Arthritis; Bursitis; Rheumatic fever.**

Rheumatology is the study of diseases affecting the body's joints and their associated tissues, including the bones, muscles, tendons, cartilage, and ligaments. Such diseases are called *rheumatic diseases.* Doctors who specialize in the care of patients with rheumatic diseases are called *rheumatologists.*

Diseases most commonly treated by rheumatologists include various forms of arthritis, particularly osteoarthritis, rheumatoid arthritis, gout, and disorders of the body's connective tissues, such as scleroderma and systemic lupus erythematosus. Rheumatologists also care for patients with general back pain and aching muscles, bones, and joints. In addition, other doctors often consult rheumatologists for help in treating patients with nonrheumatic diseases that involve the joints, muscles, and bones. Rheumatologists do not perform surgery, but they often work closely with orthopaedic surgeons and specialists in rehabilitation medicine.

Research in rheumatology often involves specialists from other fields, such as biochemistry, cell biology, genetics, immunology, and molecular biology. Some researchers search for the causes and cures of rheumatic diseases, and others study how a rheumatic disease progresses.

Rhine River is the most important inland waterway in Europe. It is about 1,320 kilometres long and drains an area of about 224,600 square kilometres. The river rises in eastern Switzerland. It forms part of the borders of Switzerland, Liechtenstein, Austria, France, and Germany. It flows through Germany and the Netherlands into the North Sea. Although there are problems of pollution from industrial waste, parts of the river are very beautiful and attract many tourists. To Germans, the Rhine is a symbol of national history. Many German legends relate to the river.

The course of the Rhine. Two glacier-fed mountain torrents rise and flow eastward in the high Alps of eastern Switzerland, close to the Italian border. One is the *Vorder* Rhine, and the other is the *Hinter* Rhine. From their union, the Rhine flows along the western borders of Liechtenstein and Austria to Lake Constance, 398 metres above the sea. This lake frees the river of its mountain mud, sand, and gravel, and sends it westward to tumble over a fall 21 metres high at Schaffhausen. From there the Rhine flows between Germany and Switzerland to Basel. This city serves as landlocked Switzerland's principal port. At Basel, the Rhine, now 205 metres wide, turns north.

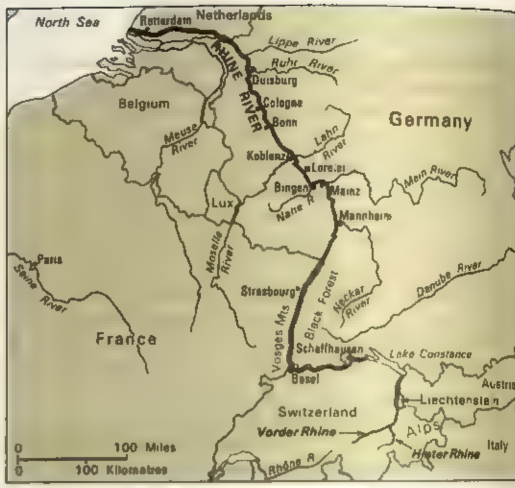
North of Basel, the Rhine flows between the Black Forest on the east and Vosges Mountains on the west. It follows a course down the middle of a plain that is about 32 kilometres wide and 290 kilometres long. In the southern part of the plain, the Rhine serves as the boundary between France and Germany. From Basel, the river gradually widens, and at Bingen, it leaves the plain and plunges into a narrow gorge through the Rhenish Slate Mountains. Here is the cliff called the Lorelei where the legendary nymph also called Lorelei lures boatmen to destruction with her song. The legends of the heroic Roland, Siegfried, and other historic and

mythical figures also developed in this region (see **Lorelei**). At Bonn, the river and valley widen again as the Rhine enters the North German Plain on its journey to the Netherlands and its broad delta leading into the North Sea.

Along its course, the Rhine receives the waters of the Neckar, Main, Lahn, Ruhr, and Lippe rivers from the east. The Nahe and Moselle rivers flow into the Rhine from the west. Canals connect the Rhine to the Danube, Elbe, Ems, Marne, Oder, Rhône, and Weser rivers and so make the Rhine part of a great inland navigation system. Dutch and German barges carry coal and petroleum products, metal ores, and cereals along the river system. North of Basel, the major Rhine ports are Strasbourg, Mannheim, Cologne, Duisburg, and Rotterdam. Duisburg is the gateway to the industrial Ruhr Valley.

The Rhine in history. The Rhine has been important in European history ever since Julius Caesar built a timber bridge across it. For 400 years, the Rhine was the boundary between the Romans and the Germanic tribes. On the west bank of the Rhine grew up the Roman cities of Cologne, or Köln (Colonia Agrippinensis), Bonn (Bonna), Koblenz (Confluentes), Mainz (Mogontiacum), all in Germany; Strasbourg (Argentoratum), in France; and Basel (Basilia), in Switzerland. During the Middle Ages, the Rhine was under German rule from Basel to the Netherlands. But when France gained a foothold on its western shore, in 1648, at the close of the Thirty Years' War, a struggle began. The struggle lasted into the 1900's. Louis XIV made gains in the Rhine Valley, and Napoleon restored the old Roman boundaries of France. Even after Napoleon was defeated, Alsace, which borders the Rhine from Switzerland to beyond Strasbourg, was left in French hands. But Germany gained almost all of Alsace in 1871.

Allied forces fought Germany for control of the same territory during World War I (1914-1918). The Treaty of



The Rhine River flows from the Alps to the North Sea.

Versailles returned Alsace and Lorraine to France, again extending that country's domain to the Rhine. Germany signed an agreement not to fortify the Rhineland. In 1936, the German dictator Adolf Hitler repudiated this agreement and began to militarize the region. He ordered the building of the *Westwall,* or Siegfried Line for defence purposes along the river at the French Frontier. During World War II (1939-1945), heavy fighting occurred along the Rhine in the last part of the European struggle. After the war, the river again became one of the world's busiest waterways.

Rhineland is a historic area in what is now Germany. It lies along the Rhine River and extends west to the borders of Belgium, France, Luxembourg, and the Netherlands (see **Germany** [physical map]).

The Rhine River in Germany winds past a cliff called the Lorelei, *centre.* According to legend, a nymph called Lorelei lured sailors to their doom, causing them to steer their boats into the cliff.

African rhinoceroses. The white rhinoceros, *left,* is the largest kind of rhinoceros. All rhinoceroses like to rest in the water after drinking. A charging black rhinoceros, *right,* is a frightening sight. Rhinoceroses have poor vision and often attack things that they do not recognize.

The Rhineland was settled during ancient times. Through the years, it was ruled by the Celts, the Romans, the Huns, and the Franks. About 800, such Rhineland cities as Cologne, Mainz, and Trier began to grow in importance, and in time became religious and political centres of the Holy Roman Empire. The Rhineland was made part of France during the Napoleonic Wars of the late 1790's. The region became part of the German state of Prussia in 1815.

The Rhineland's rich mineral resources and location on the Rhine River led to the growth of important industrial centres there, including the Ruhr coal-mining district. After World War I (1914-1918), Germany signed treaties agreeing not to fortify the region or station troops there. But German troops occupied the Rhineland in 1936 and used it for military purposes during World War II (1939-1945). Today, the area is one of Germany's major industrial districts. Tourists visit the Rhineland to see its picturesque towns, historic castles, and extensive vineyards.

The great Indian rhinoceros has skin that resembles a suit of armour. Its hide includes large folds of skin and bumps that look like rivets. This rare animal lives in eastern India.

Rhinitis is an inflammation of the mucous membranes that line the nose. The inflammation increases the production of nasal mucus and can make breathing through the nose difficult. Rhinitis can result from infections, allergic reactions, and unknown causes. It occurs most frequently as part of the common cold, a viral infection. Many other cases result from hay fever. Certain *chronic* (long-lasting) forms of rhinitis can cause the mucous membranes to thicken or to wear away. See also **Cold, Common; Hay fever.**

Rhinoceros is a huge animal that ranks as one of the largest land creatures. The rhinoceros has an immense, solid body, and short, stocky legs. Its thick skin appears to lie in folds but is actually just creased at the joints. Most *species* (kinds) have little hair. Depending on the kind, the rhinoceros has one or two slightly curving horns that project from its long nose. The horns continue to grow throughout the life of the rhinoceros. The horn consists of a fibrelike material similar to a mixture of hair and fingernails. It appears to be permanently joined to the rhinoceros' nose but can be torn out during fighting. The name *rhinoceros* comes from two Greek words and means *nose-horned.*

The animal has three toes on each foot. Each toe ends in a separate hoof. On each front foot is a fourth toe that is *rudimentary,* or no longer used. The rhinoceros differs from the hippopotamus, which has four developed toes and is a relative of the camel, cow, and pig. The rhinoceros is more nearly related to the horse.

The rhinoceros eats grass, leafy twigs, and shrubs. In captivity, it is fed hay and special protein and mineral biscuits. Wild rhinoceroses live in Africa, in southeastern Asia, and on a few large islands near the Asiatic

coast. In prehistoric times, they also roamed over Europe, North America, and northern Asia.

Baluchitherium, a prehistoric relative of the modern rhinoceros, was larger than any land mammal that lives today. This animal reached over 5 metres in height. Rhinoceroses have been known to live almost 50 years.

Kinds of rhinoceroses. There are five species of rhinoceroses. Three of them live in Asia and two live in Africa.

The *Indian rhinoceros* is the largest of the three Asian species. It stands about 1.5 metres high at the shoulder and weighs about 2 metric tons. It has one great blue-black horn, very thick at the base and about 30 centimetres long. In rare cases, the animal may stand up to 2 metres with a horn 60 centimetres long. The skin of the Indian rhinoceros is sprinkled with round knobs. It hangs in such definite folds that the beast looks as though it were wearing armour plate. But the hide can be pierced by a knife or bullet. The animal lives in marshy jungles among reeds and tall grass, on which it feeds morning and evening. The ancient people of Oriental countries knew this rhinoceros well. It was even used in the circus games in Rome before the time of Christ.

The similar one-horned *Javan rhinoceros* once ranged from eastern Bengal into Burma, and southward to Java, Borneo, and Sumatra. It is now nearly extinct.

The *Sumatran* species is smaller than any other rhinoceros and has two horns. It stands about 1.5 metres tall and weighs about 1 metric ton. It is hairy, especially on the tail and ears. The young have more body hair than the adults. This rare species also lives in Borneo and on the Malay Peninsula. Both the Javan and Sumatran rhinoceroses are found in forested hills. An estimated 1,650 rhinoceroses live in the wild in Asia.

The two African species are two-horned. They are known as the *black rhinoceros* and the *white rhinoceros,* although they are almost the same bluish-grey colour. *Hook-lipped* (for the black) and *square-lipped* (for the white) are better names for them.

The black rhinoceros has a front horn that is sometimes as much as 105 centimetres long. It uses this horn


The mouth of a rhinoceros is suited for the animal's food. The white, or *square-lipped,* rhinoceros uses its flat lips, *left,* to break off grass. The black, or *hook-lipped,* rhinoceros uses its pointed upper lip, *right,* to grasp small branches. The two species have a similar bluish-grey colour.

A baby rhinoceros begins to grow horns soon after birth. This 3-month-old white rhinoceros has a small horn. Rhinoceroses have three toes on each foot. Each toe has a hoof.

Rhinoceroses cool off by wallowing in mud or water. The mud dries on the animal's hairless skin, shielding it from the sun and protecting it from the sun and from insect bites. A rhinoceros needs mud or water for cooling because its thick hide has no sweat glands.

for defending itself and for digging. The rear horn may be the same length or shorter. The digging horn is so strong that the animal easily uproots and overturns bushes and small trees with it. Then it feeds on the leaves. This rhinoceros lives on dry plains covered with tall brush. It remains hidden by day and wanders about at night in search of food and water. Although it appears clumsy, it can move swiftly.

The white rhinoceros is the largest of all rhinoceroses. It stands about 1.5 metres tall. In some cases, it may be over 1.8 metres tall and 4.5 metres long. It weighs about 3 metric tons. The horns of the female are longer but more slender than those of the male. This is also true for the black rhinoceros. A record white-rhinoceros horn measured 157 centimetres.

Protecting the rhinoceros. All species, especially the Asian species, are nearly extinct. Rhinoceroses are greatly threatened by *poachers*—people who illegally hunt animals. Poachers kill rhinoceroses and sell their horns and skin. Many Asian people believe that the powdered horn of the rhinoceros has healing qualities and can be used to cure lung and chest illnesses. Some people believe the horn has magical powers. Asian people also use the skin, blood, and urine to cure illnesses. For all these reasons, thousands of rhinoceroses have been needlessly killed.

Laws of many countries and international trade treaties are designed to protect the rhinoceros from poachers. In the African nations of Kenya and Zimbabwe, special teams of rangers are on constant watch over the animals. In addition, efforts have been made to increase the population of certain species. For example, black rhinoceroses have been sent to Australia and the United States to form breeding colonies for future repopulation.

Scientific classification. Rhinoceroses make up the family Rhinocerotidae. The Indian rhinoceros is *Rhinoceros unicornis;* the Javan is *R. sondaicus;* the Sumatran is *Dicerorhinus sumatrensis;* the black is *Diceros bicornis;* the white is *Ceratotherium simum.*

See also Animal (pictures: Animals of the grasslands).

Rhinocerus beetle. See Beetle (picture).

Rhizoid. See Moss; Plant (Bryophytes).

Rhizome is a horizontal stem that grows at or just below the soil surface. Rhizomes produce leaves and flowers that rise above the soil, and small roots below. They can also produce buds that develop into branches. Some nonwoody perennial plants, such as iris, ginseng, wild ginger, and bloodroot, have rhizomes. Ginger root, an ingredient in Oriental cooking, is a rhizome. In many plants, rhizomes function as an organ for storing food.

See also Bulb; Orrisroot; Perennial.

Rhode Island (pop. 1,003,464) is the smallest state in the United States. It covers only 3,140 square kilometres. The state lies on Narragansett Bay, an arm of the Atlantic Ocean. It includes 36 islands, but most of the state is on the U.S. mainland. Rhode Island's nickname is the *Ocean State.*

Rhode Island is one of the smallest U.S. states in population. Providence is the largest city, chief economic centre, and state capital. Warwick and Cranston are the next largest cities.

Land. The northwestern third of Rhode Island has many hills. They include 247-metre Jerimoth Hill, the state's highest elevation. Lowlands cover the rest of the mainland, the state's 36 islands in Narragansett Bay, and the land east of the bay. The lowlands include many plains and sandy beaches. Rocky cliffs are found on the islands and shores along the bay.

Rhode Island has a fairly mild climate. January temperatures average −2° C and July temperatures 22° C.

Economy. Manufacturing is the single most important economic activity in Rhode Island. The production of jewellery and silverware is the most important manufacturing activity. The state's other manufactured products include communication equipment, hardware, and printed materials.

Service industries employ over two-thirds of the state's workers. Providence is a leading centre of finance and trade in the New England region of the United States. Business services and education are among Rhode Island's major employers.

Greenhouse and nursery products are the leading source of agricultural income in the state. In the local fishing industry, clams and flounder are the most valuable catches.

Thousands of holidaymakers visit the coastal resorts of Rhode Island each year. The resorts in the state offer swimming, boating, fishing, and beautiful scenery. Rhode Island's leading resort centres include Block Island, Narragansett Pier, Newport, and Watch Hill. In addition, tourists can also visit the many historic sites, colonial buildings, and old churches in Rhode Island.

History. A few thousand Algonquian Indians lived in the region before white people arrived in the 1500's. Some historians believe an Italian navigator, Giovanni de Verrazano, named Rhode Island after the Island of Rhodes in the Mediterranean Sea. Others believe the Dutch navigator Adriaen Block named the region *Roodt Eylandt* (Red Island).

On May 4, 1776, Rhode Island became the first American colony to declare its independence from Great Britain. Rhode Island became a U.S. state on May 29, 1790.

Textile manufacturing, the state's first important industry, grew rapidly during the late 1700's. It began a decline during the 1920's. By the end of the 1960's, the state had a varied economy. The state's jewellery and textile industries faced increasing foreign competition in the 1980's.

Rhode Island is in the northeastern United States in the area known as New England. It is on the Atlantic Ocean.

Rhodes is one of the Dodecanese Islands in the Aegean Sea. It lies 19 kilometres off the southwestern coast of Asia Minor. For location of the island of Rhodes, see **Greece** (map). Rhodes (also called Ródhos) has an area of 1,398 square kilometres and a population of about 91,000. A range of mountains runs lengthwise across the island and rises to a height of 1,215 metres above the sea. Orchards, farms, and vineyards in the fertile valleys produce oranges, olives, tobacco, and grapes. Sponges are the chief export. Rhodes is a popular tourist centre.

In early days, Rhodes was a wealthy and independent state of Greece. It was the home of many poets, artists, and philosophers. A great statue of Helios, called the *Colossus of Rhodes,* was one of the Seven Wonders of the Ancient World (see **Seven Wonders of the Ancient World**). In 1310, the Knights Hospitallers of Saint John occupied Rhodes and held it until 1522. Then Ottoman Turks took control of the island, and Rhodes declined.

Italy occupied Rhodes during the Turko-Italian War of 1911-1912. After the war, Turkey lost Rhodes and 13 other Aegean Islands to Italy. After World War II (1939-1945), Italy ceded Rhodes and the rest of the Dodecanese Islands to Greece. The capital of the islands is the city of Rhodes (or Ródhos).

Rhodes, Cecil John (1853-1902), was a British businessman and statesman. He made a fortune in the diamond industry and probably did more than anyone else of his time to enlarge the British Empire in Africa. Rhodes used his wealth and his ability as a statesman to gain control of most of southern Africa. He spent his fortune freely when he thought he could advance the empire. But he was often ruthless and racist in pursuing his goals. Rhodes left much of his fortune to Oxford University for the establishment of the Rhodes Scholarship (see **Rhodes Scholarship**).

Early life. Rhodes was born in the county of Hertfordshire in England. In 1870, he went to Natal (a British colony in what is now South Africa), where one of his brothers was a cotton grower. In 1871, he became a supervisor in a diamond mine his brother had opened at Kimberley, also in present-day South Africa. By 1873, Rhodes had taken control of the mine. Rhodes enrolled at Oxford University in 1873 and spent half of each year there until he graduated in 1881. He also gained control of more diamond mines at Kimberley.

Gains Rhodesia. In 1881, Rhodes was elected to the assembly of the United Kingdom's (UK's) Cape Colony in what is now South Africa. Aided by his wealth, he set out to advance British imperial authority in southern Africa. He forced the annexation of Bechuanaland (now Botswana) to the British Empire in 1885. By 1888, when he combined all his mines into the De Beers Consolidated Mines, Rhodes had become extremely rich and powerful. In 1889, he forced the Shona and Ndebele (often called Matabele) peoples to surrender most of their land to the UK. This huge territory later became the state of Southern Rhodesia (now Zimbabwe). Rhodes also arranged the annexation of what later became Northern Rhodesia (now Zambia). The British South Africa Company, which Rhodes had created, effectively ruled both territories.

Cecil Rhodes

In 1890, Rhodes became prime minister of the Cape Colony. He dreamed of extending British power over much of Africa. He also sought cooperation between English-speaking white colonists and moderate *Boers* (white settlers, mostly of Dutch descent).

In 1892, Rhodes approved the Franchise and Ballot Bill, which denied almost all the colony's black Africans the right to vote. In 1894, he enacted laws that restricted the amount of land black people could own.

Conflict with the Boers. In 1890, Rhodes met Paul Kruger, president of the Boer republic in the Transvaal, to discuss a possible federation. But Rhodes also interfered in the politics of the republic. He was largely responsible for the Jameson Raid of 1895, in which Rhodesian troops invaded the Transvaal in an attempt to overthrow the government there. Boer forces captured the invaders, and the incident destroyed Rhodes's political career. He resigned as prime minister of the Cape Colony and withdrew to Rhodesia.

Rhodes was at Kimberley in 1899 when the Anglo-Boer War finally broke out between the UK and the Boers (see **Anglo-Boer Wars**). He assisted in the defence of the city and helped direct the course of the war. But he had a fatal heart attack before the war ended.

Rhodes Scholarship is an award that enables students from many countries to study at Oxford University in England. The scholarship pays the student's tuition fees and also provides an allowance to cover living expenses. Scholarships are awarded for two years, but are sometimes extended for a third year.

The scholarships were established in the will of Cecil Rhodes, a British colonial statesman. The scholarship programme began full operation in 1904.

About 100 Rhodes Scholarships are awarded yearly. The United States receives 32; Canada, 11; South Africa, 9; Australia, 17; India, 13; New Zealand, 2; and Germany, 2. Zambia and Zimbabwe send three scholars each every two years. Bermuda, Jamaica, Pakistan, Hong Kong, Malaysia, Singapore, Kenya, Nigeria, and the British Caribbean, are each offered one Rhodes Scholarship each year.

In addition to superior scholastic records, candidates must display qualities of character, leadership, and show interest in outdoor sports. Applicants must be unmarried, at least 18 years old and not older than 24. They also must have completed enough college education to ensure that they will receive a bachelor's degree before they arrive in Oxford. Women became eligible for the award in 1976.

See also **Oxford University; Rhodes, Cecil John.**

Rhodesia. See Zimbabwe.

Rhodesia and Nyasaland, Federation of, was a federated territory in central Africa from 1953 to 1963. It belonged to the United Kingdom (UK). The federation consisted of the self-governing colony of Southern Rhodesia and the protectorates of Northern Rhodesia and Nyasaland. The UK created the federation in 1953.

The UK agreed to dissolve the federation on Dec. 31, 1963. In 1964, Nyasaland became the independent

nation of Malawi and Northern Rhodesia gained independence as Zambia. Southern Rhodesia became the self-governing area of Rhodesia, which is now the independent nation of Zimbabwe.

See also **Malawi; Zambia; Zimbabwe.**

Rhodesian ridgeback is a medium-sized hound that originated in southern Africa. It is also called the *African lion hound* because it was bred to find and hold off lions so that hunters could get a good shot at their prey. The dog has a ridge of hair on the back that grows in a direction opposite to the rest of the coat. The coat has a

The Rhodesian ridgeback is a powerful hunting dog that originated in southern Africa. It was once used to hunt lions.

light to reddish-wheatlike colour. The ridgeback stands 60 to 70 centimetres high at the shoulder and weighs between 30 and 35 kilograms. It makes an excellent watchdog and is good with children.

See also **Dog** (picture: Hounds).

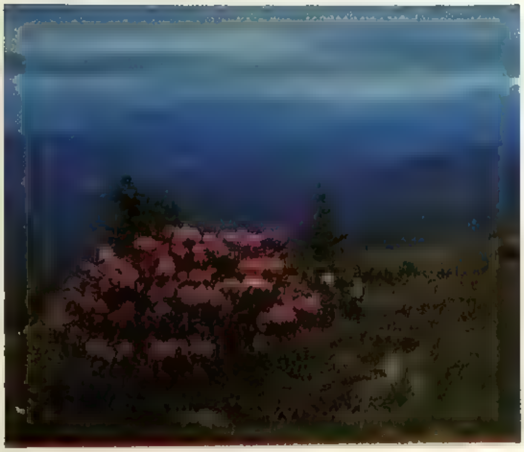
Rhodium is a rare, silver-white, metallic element that serves mainly as a *catalyst,* a substance that increases the speed of a chemical reaction. Rhodium is a catalyst in the production of nitric acid and various organic compounds and medicinal drugs. It is also used in *catalytic converters,* which reduce pollutants in car exhausts. Rhodium *alloys* (metal mixtures) are used in aircraft turbine engines, electric connections, and reflective surfaces of mirrors and searchlights.

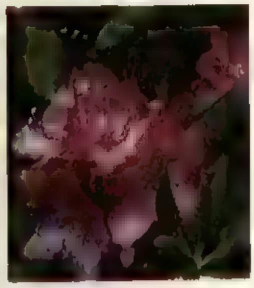
Rhodium has the chemical symbol Rh. Its atomic number is 45, and its atomic weight is 102.906. Rhodium melts at 1966 °C and boils at 3697±100 °C. William Wollaston, an English chemist, first isolated rhodium in 1803. Rhodium occurs in Brazil, Canada, Colombia, Russia, South Africa, and Sri Lanka.

See also **Element, Chemical** (Periodic table).

Rhodochrosite. See **Mineral** (picture: Common minerals with nonmetallic lustre).

Rhododendron is the name of a group of trees and shrubs, many of which are known for the beauty of their flowers and for their evergreen leaves. The word *rhododendron* means rose tree. There are about 1,200 species of rhododendrons. More than 700 of these are native to the region where several of the great rivers of Asia break through the Himalaya. Another group of almost 300 species occurs in New Guinea. The remaining rhododendrons originate mainly from Japan and southern Asia.





The rhododendron has large clusters of colourful flowers that make this evergreen plant a popular ornamental shrub. The showy blossoms, *right,* appear in the spring. Rhododendrons generally grow in cool, mountainous regions.

Rhododendrons range from small, creeping shrubs to 20-metre trees. The magnificent *Rhododendron sinogrande* is an evergreen tree growing up to 17 metres. Native to China, Burma, and Tibet, it has yellow, bell-shaped flowers with a crimson blush inside. Its leaves grow to more than 60 centimetres long, and are deep green above and silver beneath. *R. griffithianum,* a 7-metre tree from the Himalaya, has the largest blossoms of all the white-flowered species.

Scientific classification. The rhododendrons belong to the heath family, Ericaceae.

Rhodope Mountains. See **Bulgaria** (Land); **Greece** (Macedonia; Thrace).

Rhomboid is a plane figure with two parallel sides of equal length, and the other two sides a different, but also equal, length. Its sides are not at right angles to each other. See also **Rhombus.**

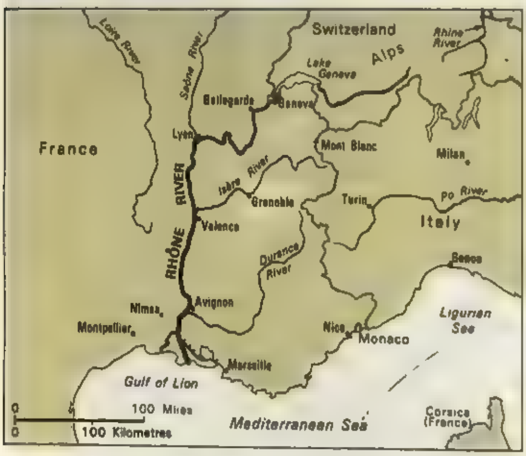
Rhombus is the name given to a plane figure with two pairs of straight, parallel sides, all of equal length. Usually, its sides are not at right angles to each other.

The area of a rhombus is found by multiplying base by altitude, or $A = bh$. The diagonals WY and XZ are perpendicular to each other. Using the two triangles ZWX and XYZ in the figure, you can show that the area of a rhombus is equal to half the product of its diagonals. See also **Quadrilateral.**

Rhondda (pop. 76,300) is a local government district and coal-mining centre in Mid Glamorgan, Wales. It lies in a valley formed by the River Rhondda, between hills that rise as high as 600 metres. Rhondda is about 13 kilometres from Pontypridd and about 32 kilometres from Cardiff. Many people call the whole valley the Rhondda. Its main towns include Gelli, Pentre, and Treorchy. Treorchy is the home of one of Wales's best-known male voice choirs. See also **Glamorgan.**

Rhône River is an important commercial waterway of France. The river has become famous for the beauty of its valley. The river rises in the Rhône glacier of Switzerland, at an altitude of over 1,500 metres. Glacial clay picked up by the river in the Swiss Alps makes the water of the Rhône almost milky. But during the Rhône's course through Lake Geneva, it loses most of the glacial clay at the bottom of that lake. The clear blue of the river, after leaving Lake Geneva, inspired the English poet Lord Byron to describe it as "the blue rushing of the arrowy Rhône."

After the Rhône leaves Switzerland and enters France, it flows southwestward to Lyon. It then winds south and empties through a large delta into the Gulf of Lion, an arm of the Mediterranean Sea.



Location of the Rhône River

The Rhône is over 800 kilometres long, and navigable for about 480 kilometres. Chief branches are the Saône, the Isère, and the Durance. Hydroelectric power plants along the Rhône generate electricity. Canals feed irrigation projects along the lower course of the river. A canal near the mouth of the Rhône connects the river with France's largest Mediterranean port, Marseille.

Greek and Latin civilizations followed the Rhône Valley to Lyon, and up its tributaries.

Rhubarb is one of the few perennial vegetables. Rhubarb originally came from Mongolia, but is grown in temperate regions of Europe and America. The plant forms a large, yellow storage root and a mass of feeder roots underground. Its *rhizome* (underground stem) produces buds from which grow long, thick leafstalks with large leaves. People use the reddish, juicy stalks for food. The leaves contain poisonous oxalic acid salts (see **Oxalic acid**).

The rhubarb plant has juicy, reddish stalks with a tangy flavour. Rhubarb, though a vegetable, is popular as a dessert.

People usually cook rhubarb as a dessert food, often as fillings for pies and also as sauces. Rhubarb is sold fresh, frozen, or in tins. Rhubarb contains some vitamin C, and has laxative qualities.

Rhubarb plants produce many seeds, but plants from the seeds are not always like the parent plant. Growers plant pieces of the big storage root that have several buds from which new plants grow. Each plant lasts 5 to 8 years. Rhubarb is relatively free from insect attack and suffers from few diseases.

Scientific classification. Rhubarb belongs to the buckwheat and sorrel family, Polygonaceae. It is genus *Rheum,* species *R. rhaponticum.*

Rhuddlan (pop. 54,000) is a local government district in Clwyd, Wales. A mainly agricultural district, it includes the seaside resorts of Rhyl and Prestatyn and the small towns of Rhuddlan and St. Asaph. Rhuddlan has the remains of an imposing Norman castle dating from 1277. In 1284, Edward I issued the Statute of Rhuddlan, defining his plans for governing Wales. St. Asaph has the smallest cathedral in the United Kingdom, built in the 1200's. See also **Clwyd.**

Rhumb line. See **Great-circle route.**

Rhumba. See **Rumba.**

Rhyme means echoing or repeating sounds at the end of words. In poetry, rhyme usually occurs at the end of lines, as in this quotation from the Irish poet William Butler Yeats:

> O body swayed to music, O brightening glance,
> How can we know the dancer from the dance?

This is an example of *end-rhyme. Glance* in the first line rhymes with *dance* in the second. *Internal-rhyme* refers to the rhyming of two or more words within a line, such as *seared, bleared,* and *smeared* in this line by the English poet Gerard Manley Hopkins: "And all is seared with trade; bleared, smeared with toil."

In *single rhyme,* the final vowel and consonant sounds of the rhyming words are repeated, as in *glance* and *dance.* In *double rhyme,* the last two syllables of the rhyming words are repeated, as in *staples* and *maples.*

Less frequently, rhymes involve many syllables, as in *Tennyson* and *venison*.

In *near rhyme* (also called *slant rhyme*), the words almost rhyme. The words repeat either (1) the final consonant sounds after the last stressed vowel sound, as in *have* and *grave*, or (2) the final stressed vowel sound but not the final consonant sounds, as in *wake* and *late*. In *visual rhyme* (also called *eye rhyme*), the words are connected by the eye, not the ear, as in *tough* and *through*.

Poets often use a rhyme pattern to create an overall form for a poem, as in a sonnet. They may also use individual rhymes for various effects of sound and meaning.

See also **Alliteration; Blank verse; Free verse; Poetry** (Sounds); **Sonnet**.

Rhyming slang is a form of code language. In most rhyming slang, the slang terms consist of two or more words each. The last word of the term is a rhyme or assonance of the word that would be used in normal speech. For example, in the rhyming slang used by the London cockneys, *tit for tat* means *hat*, and *butcher's hook* means *look*. People who speak in rhyming slang often omit the rhyming words. A cockney speaker might say *Take a butcher's at that titfer* for *Look at that hat*. Some phrases from cockney rhyming slang are well known and used in everyday speech. For example, the phrase *brass tacks* originated as rhyming slang for *facts*. Cockney slang may have developed as a code used by thieves. See also **Cockney; Slang.**

Rhymney Valley (pop. 101,400) is a local government district in Mid Glamorgan, Wales. It occupies the valley of the River Rhymney, north of Cardiff. Coal mining was traditionally the main industry, but light industry and tourism are now more important. Hengoed is a coal-mining centre. The district's chief town is Caerphilly. Its castle dates from the 1200's. The village of Gelligaer has the remains of an ancient Roman fort. See also **Glamorgan.**

Rhyolite. See Granite.

Rhys, Jean (1894-1979), a Dominican-born author, wrote novels, short stories, and poetry. Her portrayals of fragility and despair establish her as a fine, understated writer. Rhys gained critical praise, but for most of her lifetime she had little popular readership.

Rhys's novels include *Quartet* (originally entitled *Postures*, 1928), *After Leaving Mr. Mackenzie* (1931), *Voyage in the Dark* (1934), and *Good Morning, Midnight* (1939). A long period elapsed before *Wide Sargasso Sea* (1966), her most successful novel, was published.

Ella Gwendolyn Rhys Williams was born in Roseau, Dominica, of a Welsh father and Creole mother. Rhys moved to England in 1907. She studied briefly to be an actress, dividing her time between London and Paris. In Paris, she met the writer Ford Madox Ford, who encouraged her and wrote a preface to her first book of short stories, *The Left Bank* (1927). Rhys's unfinished autobiography, *Smile Please*, was published shortly after her death in 1979.

Rhythm is the regular repetition of a beat, accent, or rise and fall in dance, music, and language. The word comes from the Greek word *rhythmos*, meaning *measured motion*. In dancing, rhythmic patterns and variations are created by physical motions of shorter or longer duration and of greater or lesser emphasis. In music, rhythmic figures and phrases come from an arrangement of tones, organized according to their duration and stresses, or accents. Rhythm is the most primitive element of music. Unlike the other elements, it can exist independently. Any sound, even noise, can establish a rhythm. In language, rhythm is the rise and fall of sounds according to syllables, vocal inflections, physical speech accents, and pauses.

Modern English and German are of the language type that has physically stressed, or accented, syllables. Greek and Latin use long and short syllables or inflections to give stress. In poetry, both language types organize syllables into rhythmic patterns called *feet*, which are grouped into many different poetic forms.

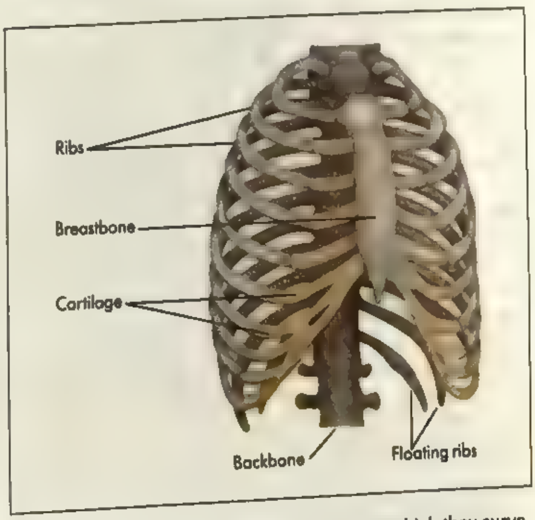
See also **Dancing; Language; Metre** (poetry); **Music** (Rhythm; Musical notation).

Rhythm method. See **Birth control** (Methods of birth control).

Rial is the basic monetary unit of Iran, Oman, Qatar, Saudi Arabia, and Yemen. It is sometimes called the *riyal*. Its value varies in each country that uses it. Its name comes from the old French and Spanish words for *royal*. The unit is sometimes incorrectly called *real*, which was the name for a silver coin of Spain.

Rib is any one of the 24 bones that enclose the chest in the human body. There are 12 ribs on each side of the body, each connected to the *vertebral column* (backbone) by small joints called *costovertebral joints*. In the front of the body, the uppermost seven ribs on each side are connected directly to the breastbone by a tough, elastic material called *cartilage*. These are called the *true ribs*. The five lower ribs, called *false ribs*, are not linked directly to the breastbone. Each of the upper three false ribs is attached to the rib above by cartilage. The lowest two ribs are attached only to the backbone. They are known as *floating ribs*. The spaces between the ribs, called *intercostal spaces*, contain arteries, veins, muscles, and nerves.

Most *vertebrates* (animals with backbones) have ribs, but the number of ribs varies considerably. In mammals



The ribs are connected to the backbone, from which they curve downward and forward to form a protective cage around the heart and lungs. The human body has 24 ribs, 12 on each side.

the number of ribs varies from 9 pairs, as in some whales, to 24 pairs, as in two-toed sloths.

The ribs perform two functions in the body. They form a cage around the chest cavity that protects the heart and lungs. They also move up and down and, together with the diaphragm, control the movement of air in and out of the lungs. When the ribs move up, the chest cavity enlarges and air is sucked into the lungs. When they move down, air is forced out of the lungs.

A hard blow on the chest can fracture a rib. Fractured ribs cause sharp pain when the injured person breathes, and tenderness when pressure is applied to the fracture area. A person who has an injured chest should call a doctor.

See also **Human body** (Trans-Vision colour picture).

Ribaut, Jean (1520?-1565), a French colonizer, led an expedition to America in 1562 to found a Huguenot colony. He built Fort Charles, where Port Royal, South Carolina, now stands. He then returned to France, and left the settlement in care of 26 colonists, who later abandoned it. In 1565, Ribaut took charge of a French Protestant settlement at Fort Caroline, on the Saint Johns River in Florida. Spaniards later captured Ribaut and his men and stabbed Ribaut to death. He was born in Dieppe, France.

Ribbentrop, Joachim von (1893-1946), was Adolf Hitler's top diplomatic agent. He served as foreign minister of Germany from 1938 to 1945. He helped engineer the seizure of Austria, the partition of Czechoslovakia, and alliances with Italy and Japan. He made a deal with Joseph Stalin, dictator of the Soviet Union, in August 1939, which safeguarded Germany's eastern border in exchange for concessions to the Soviet Union. After World War II (1939-1945), he was tried and hanged for war crimes.

Ribbentrop was born in Wesel, Germany. He studied in France, and worked in both the United States and Canada. His familiarity with different languages helped him greatly in diplomacy. In 1935, he signed a naval treaty with England which gave Germany equality in submarines.

Ribble Valley (pop. 51,000), a borough and local government district in Lancashire, England, occupies part of the course of the River Ribble. The Ribble, 120 kilometres long, rises in the Pennine Hills of North Yorkshire and flows through Lancashire to the Irish Sea. The Ribble Valley's beautiful countryside contains the town of Clitheroe. Clitheroe has textile and engineering industries and the remains of a castle built in the 1100's. See also **Lancashire**.

Ribbon worm is any of a group of worms with a long slender *proboscis* (snout). The proboscis lies in a tubular space above the mouth and can be thrown out quickly and wrapped around the prey. In some ribbon worms, the proboscis has daggerlike *stylets*. In others, it has *nematocysts* (fine stinging threads). Ribbon worms feed on other animals such as worms and molluscs, both living and dead. They are not harmful to people. Most ribbon worms live in the ocean, but a few live in moist earth and fresh water. They range in size from less than 2.5 centimetres to as much as 25 metres long. Some ribbon worms are brilliantly coloured.

Scientific classification. Ribbon worms make up the phylum Nemertina.

Ribera, Jusepe de (1588-1652), was a Spanish painter. Many of his paintings show Christian martyrdoms and saints doing penance. Until 1635, Ribera's style showed the influence of the Italian painter Michelangelo Caravaggio. Ribera then used sombre colours and placed realistic figures in simple, diagonal compositions. Between 1635 and 1639, influenced by the Italian painters Correggio and Titian, he used brighter colours and more complex compositions. Elements of these earlier styles are found in his work after 1639.

Ribera was born in Játiva, near Valencia, Spain. In 1616, he settled in Naples, Italy, then a Spanish territory. He became very successful and never returned to Spain. The Italians nicknamed him *Lo Spagnoletto* (Little Spaniard).

Riboflavin. See **Vitamin; Nutrition** (Vitamins).

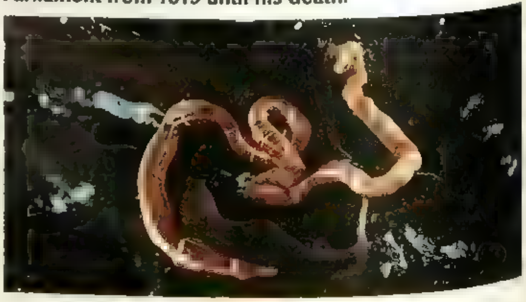
Ricardo, David (1772-1823), was the leading British economist of the early 1800's. He helped establish the theories of *classical economics,* which stress economic freedom through free trade and free competition.

In his book *Principles of Political Economy and Taxation* (1817), Ricardo defined the conditions that would enable a country's economy to reach its greatest potential. He believed that the accumulation of capital was the key to rapid economic growth. He argued that allowing businesses to seek high profits would bring about a rapid accumulation of capital.

Ricardo considered labour to be the most important source of wealth. But he also thought that population growth would push wage rates down to a level that would barely support the people. As the economy expanded and the population continued to grow, land rent would rise. This would reduce profits, the accumulation of capital would slow down, and economic growth would end. But Ricardo believed that by this time industrialization would have spread throughout the world and peak production would be a reality.

Ricardo's theories influenced other economists. His theory of comparative advantage is still the basis for the modern theory of international trade (see **International trade**). Karl Marx was influenced by Ricardo's *labour theory of value,* which held that the value of a commodity is determined by the amount of labour needed in its production. Henry George, a land reformer, developed Ricardo's theory of rent into a detailed study of progress and poverty. John Stuart Mill, a British philosopher and economist, used Ricardo's ideas as the basis for a philosophy of social reform.

Ricardo was born in London, and made a fortune on the stock exchange while still in his 20's. He served in Parliament from 1819 until his death.



A ribbon worm has a thin, ribbon-like body.

Farmers cultivate rice on many kinds of land. In hilly areas, they build terraces and *dykes* (earth walls) to catch rainfall for growing rice, *left.* In lowland regions, farmers plant rice in fields that are surrounded by dykes and then flooded, *right.* Rice is one of the world's most important food crops.

Rice

Rice is one of the world's most important food crops. More than half of the people in the world eat this grain as the main part of their meals. Nearly all the people who depend on rice for food live in Asia. In some Asian languages, the same word means *eat* and *eat rice.* In Sanskrit, the ancient and sacred language of Hindus in India, rice is given a second name which means "sustainer of the human race". Most rice is eaten as boiled, white grain.

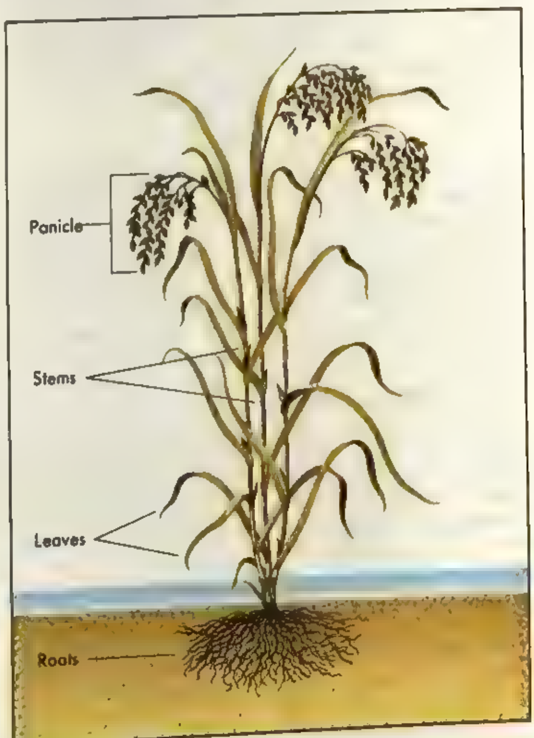
Rice is a cereal grain. Like other cereal grains, including wheat, maize, and oats, rice belongs to the grass family. But unlike other grains, rice grows best in shallow water. Rice thrives in many tropical areas because of their warm, wet climate. Farmers usually flood rice fields to supply the growing plants with moisture and to kill weeds and other pests. China and India are the world's leading rice-producing countries. Together, they produce more than half of the world's yearly rice harvest.

A type of grass called *wild rice* grows in central Canada and parts of the Northern United States. In spite of its name, this grain is not closely related to rice.

The rice plant

Young rice plants have a bright green colour. As the grain ripens, the plants turn golden-yellow. The grain becomes fully ripe from 110 to 180 days after planting.

Structure. The main parts of a mature rice plant are the roots, stems, leaves, and head. A system of slender



The rice plant grows from 80 to 180 centimetres tall and has several stems. At the end of each stem is a *head,* or *panicle,* which holds the kernels of rice. Each panicle bears from 60 to 150 kernels.

roots supports the plant's hollow stems. Each stem has at least five or six joints from which the long, narrow leaves grow. The head, also known as the *panicle,* grows from the top joint. The panicle holds the *kernels* —that is, the seeds or grains—of the rice plant. Each panicle carries from 60 to 150 kernels.

A typical rice kernel is 6 to 10 millimetres long. The kernel has a hard covering called a *hull* that is not good to eat. Underneath the hull are the *bran layers,* the *endosperm,* and the *embryo.* Several bran layers provide a tough coat for the kernel. They contain many of the kernel's nutrients. The starchy endosperm makes up most of the kernel. It is the part of the kernel most often eaten. The tiny embryo is the part of the kernel from which a new plant grows.

Growth and reproduction. A new rice plant develops from the embryo inside the seed. The seed begins to sprout a few days after it is exposed to warm temperatures and plentiful moisture. The first *tiller* (shoot) appears 5 to 10 days after planting. Some varieties of the rice plant may send out as many as 50 tillers, but most grow far fewer. More leaves appear as the tillers grow taller. The panicle grows from the top of the tiller. Older varieties of rice grow from 120 to 180 centimetres tall. But some newer varieties stand from 80 to 100 centimetres high.

Rice plants begin to develop flowering parts 6 to 10 weeks after planting. The panicle forms inside the *sheath*—a tubelike, leafy covering that surrounds the stem. After about 4 weeks, the panicle emerges from the sheath and bears flowers. Pollination must occur for grains of rice to develop. Rice can pollinate itself because each flower has both male and female reproductive parts (see **Pollen**). The flowers give rise to mature grains of rice 4 to 6 weeks after pollination.

Uses of rice

Food. Nearly all the rice produced in the world provides food for people. Rice supplies about half the calories in the daily diet of many people in Asia. It is an excellent source of *carbohydrates*—nourishing substances that provide the body with energy. Although low in protein, rice becomes an important source of protein if eaten in large amounts. Rice also has small amounts of the B vitamins—niacin, riboflavin, and thiamine—and the minerals iron, phosphorus, potassium, and sodium. Rice has very little fat and is easy to digest.

Most rice is eaten as *milled white rice*—rice that has had both its hull and bran layers removed during milling. Conversion of raw to milled rice causes weight losses of up to 72 per cent; the hull accounts for more than 20 per cent of the weight and there are also losses of about 5 per cent from dead grains and other impurities. In most developing countries, milling methods are primitive and involve the use of a pestle and mortar worked by hand, or foot, or water power. These methods remove only a little of the bran layer. *Brown rice* has had its hull removed but not its bran layers. Brown rice is more nutritious than white rice because the bran layers contain most of the kernel's vitamins and minerals. However, many people prefer white rice because it is less chewy than brown rice and takes about half as long to cook.

White rice may be treated in various ways to make it more nutritious. For example, much white rice is *enriched* with vitamins and minerals to replace the nutrients lost in removing the bran. In areas where rice is the main food, enrichment helps prevent *beriberi,* a disease caused by lack of thiamine (see **Beriberi**).

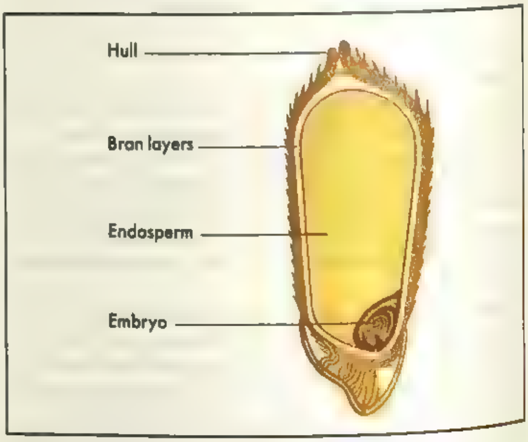
Rice may also be steamed under pressure with the hulls on before milling. This process, called *parboiling,* makes the kernels less likely to break during milling. In addition, parboiled rice keeps many of the vitamins and minerals usually lost during milling because these nutrients spread throughout the grain during parboiling. *Quick-cooking rice* is partially cooked after milling. The kernels become more absorbent in the process and need less time for final cooking.

Other uses. Rice appears in many processed foods, including certain breakfast cereals, soup, baby food, snack foods, frozen foods, and flour.

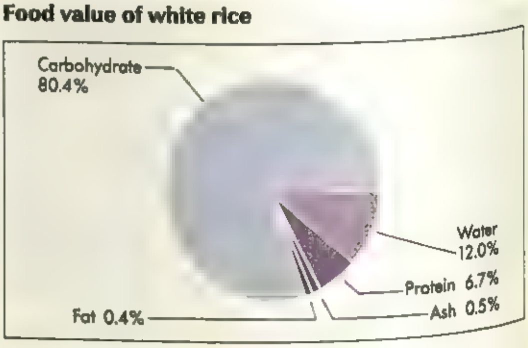
Breweries use broken rice kernels to make *mash,* an important ingredient in beer (see **Brewing** [Mashing]). In Japan, rice kernels are used to make an alcoholic drink called *sake,* or rice wine. In China an alcoholic drink called *wang-tsin* is made from rice with the addition of fungi.

Farmers may use rice hulls for fertilizer and add bran layers to livestock feed. In industry, hulls are sometimes used as an ingredient in such products as insulation, cement, and the liquid chemical *furfural* (see **Furfural**). A few producers extract cooking oil from the bran. Many people in Asia use the *straw* (dried stalks) from rice

Cross section of a grain of rice



Food value of white rice



plants for a wide range of purposes. These include thatching house roofs and weaving to produce sandals, hats, and baskets.

Kinds of rice

Scientists have identified 20 species of rice. But only two species are cultivated today—Asian rice and African rice. Nearly all cultivated rice is Asian rice. A small amount of rice is grown in Africa, mostly in the western part of the continent.

Asian rice can be divided into three main groups: Indica, Japonica, and Javanica. Indica rice is grown in India and other tropical regions of the world. Japonica rice is cultivated in the cooler areas of Asia, including China, Japan, and Korea. Japonica rice is also grown in Europe, North America, and Australia. The third type, Javanica rice, is grown in Indonesia. Within these three groups, agricultural researchers have identified more than 70,000 varieties.

Growers classify rice into three types by the length of its grain. Short grain rice is less than 5 millimetres long. Medium grain rice ranges in length from 5 to 6 millimetres; and long grain rice, from 6 to 8 millimetres. Long grain rice contains a large amount of *amylose,* a starch that makes the rice dry and fluffy when it is cooked. Both short and medium grain rice have less amylose and so become moist and sticky when they are cooked. Most tropical varieties of rice have long grains. Most varieties of rice grown in milder climates have short or medium grains.

Rice may also be classified by how it is cultivated. *Lowland rice* is grown in flat fields that are flooded by irrigation. Banks of earth enclose the land into fields called *paddies.* About a third of the world's rice is lowland rice.

Upland rice grows in areas too hilly for flooding. Such rice depends on rainfall for moisture. Upland rice accounts for about a sixth of the total rice production.

The remaining half, called *rainfed paddy* rice, combines features of lowland and upland cultivation methods. It grows in paddies watered by rainfall rather than irrigation.

Researchers are able to produce *hybrids* by crossing (mating) two different varieties of rice. Some farmers in China grow hybrid rice. However, few other farmers cultivate hybrids because growing them requires too much work.

Leading rice-growing countries

Figures are for a three-year average, 1989-1991.
Source: Food and Agriculture Organization of the United Nations.

Where rice is grown

Farmers grow rice in more than 100 countries. In all, they plant about 145 million hectares of rice each year and harvest about 475 million metric tons. Rice grows best in areas with warm temperatures and with plentiful moisture from rainfall or irrigation. Such favourable conditions occur mainly in many tropical regions and the valleys and deltas of certain rivers. These rivers in-

Rice-producing areas of the world

China and India produce more than half of the world's rice. Other major rice-producing countries include Bangladesh, Burma, Indonesia, Japan, Thailand, and Vietnam.

Major rice-producing area

Other rice-producing area

clude the Yangtze in China, the Ganges in India, and the Mekong in Vietnam.

Asian farmers grow about 90 per cent of the world's rice. China and India are the leading producers. Together, they grow more than 50 per cent of the world's rice. Other top producers include Bangladesh, Burma, Indonesia, Japan, Thailand, and Vietnam. Rice is grown in 10 European countries which produce a total of almost $2\frac{1}{2}$ million metric tons annually.

Large-scale immigration from Far Eastern and Middle Eastern countries combined with changing food habits have caused a number of European countries to become major importers of rice. The United Kingdom eats 300,000 metric tons of rice a year. France, which grows 65,000 metric tons in its southern regions, imports 200,000 metric tons annually.

Rice growing in Australia is an expanding, highly efficient industry. More than 1,500 Australian farms grow about 800,000 metric tons annually, of which 90 per cent is exported.

Nearly all rice is eaten in the country where it is grown. Less than 5 per cent of the world's rice crop is traded internationally. A few countries regularly import rice. Other nations import rice if their crop fails.

The chief exporters of rice include Thailand, Pakistan, China, and the United States. The United States exports about 40 per cent of its crop each year.

How rice is grown

Methods of growing rice vary, depending on the supply of labour and the level of *mechanization* (work done by machinery). In Southeast Asia and other developing regions, labour is plentiful, and most of the work is done by hand. Some farmers have oxen or water buffaloes for pulling ploughs. In developed countries, farmers use machinery for most stages of production.

Most rice grows in areas of the world with a yearly rainfall of at least 100 centimetres. But farmers can cultivate rice in drier regions by irrigating the land. Rice needs an average temperature of at least 21° C throughout its growing season. It grows best in heavy, slightly acid soils that contain fine particles of clay. Such soils hold water well.

Planting rice seeds along earth ridges may be done by hand, *above*, or by machine. Many Asian farmers plant small seedbeds and later transplant the seedlings to a flooded field.

Growing rice involves four main steps: They are (1) preparing the ground, (2) planting, (3) controlling diseases and pests, and (4) harvesting.

Preparing the ground. Rice grows best in a field covered with shallow water. Farmers build low earth walls called *dykes* or *levees* to hold water in the paddies. Many Asian farmers flood their fields before levelling them. They work the soil into a soft mud to make it easier to plough and to bury weeds. The practice of working flooded land is called *puddling*.

In developed countries most rice growers level the ground with large earth movers. They make sure the land slopes slightly so it can drain quickly before the harvest. They use specialized machines to *till* (plough) the land and build dykes. Before planting, farmers may add mineral fertilizers to the soil to enrich it. The most commonly applied fertilizers are nitrogen, phosphorus, and potassium.

Planting. In developing countries, farmers sometimes plant rice seeds directly in the ground. More com-

Most rice farming in Asia is done by hand. Seedlings are transplanted from beds into flooded fields, *left*. At harvest, farmers cut the rice stalks with knives or sickles and tie the stalks into bundles to dry, *centre*. The dried stalks are then beaten against "screens" to separate the grain, *right*.

Rice growers in developed countries use crop-duster aeroplanes and other machines. This plane is spraying weedkillers.

monly, however, they sow seeds thickly in small seedbeds and transplant the seedlings to a flooded field after several weeks. This method reduces the length of time rice occupies the main field by about 15 to 20 days. This is important in areas where several crops are grown on the same land each year. Transplanting seedlings also permits better weed control. Fewer weeds are able to grow in the thickly sown seedbeds. In addition, farmers can remove weeds more easily in the main rice fields when the plants are larger.

Farmers transplant clumps of 3 to 6 seedlings into the muddy soil. The clumps are spaced 10 to 20 centimetres apart and may be lined up in rows.

In industrialized nations, many rice growers use a machine called a *drill* to place the seeds directly in the soil. After planting if the soil's moisture is low, they may flood the field briefly and then drain it so that the seeds can sprout and grow. The field may be flooded and drained a few more times before the plants reach a height of 8 to 15 centimetres. A layer of water 5 to 20 centimetres deep is then left in the field until a few weeks before harvest. Some rice growers scatter seeds onto a flooded field from a small, low-flying aeroplane. The seeds are allowed to sprout before they are sown to help speed their growth and to ensure that they sink in the water. Fertilizers also may be sprayed on the plants from an aeroplane.

Controlling diseases and pests is an important part of growing a good rice crop. Fungi, bacteria, and viruses infect rice plants with diseases. Weeds compete with rice plants for nutrients in the soil. Such destructive insect pests as leaf hoppers and stem borers also attack rice. Farmers use chemicals to control many of these enemies. However, since many of these chemicals may be harmful to people and the environment, farmers must use care in applying them. Rice growers can best protect their crop from damage by planting varieties that can resist diseases and pests.

Harvesting. Farmers drain the rice fields two to three weeks before the harvest. The grain is ready for harvesting when moisture makes up 18 to 25 per cent of its weight. The wet rice must be dried after harvesting, before storage and milling.

In developing countries, farmers harvest the rice by hand. They usually cut the stalks with sickles or knives, tie the stalks in bundles, and dry them in the sun. The crop is then ready for *threshing,* the process of separating the grain from the rest of the plant. The farmers may thresh the grain by beating the panicles against a slatted bamboo screen and letting the grain fall between the slats. Some farmers put the bundles of rice through a gasoline-powered thresher. In some areas, farm animals walk over the bundles to thresh the grain. If the grain needs further drying after threshing, it is spread out on mats in the sun.

In industrialized countries, large self-powered machines called *combines* harvest and thresh rice in one operation. The wet grain is then dried by heated air.

How rice is processed

Harvested rice, still in its hull, is called *rough rice* or *paddy rice.* Most rough rice is processed in mills and sold as milled white rice. Millers use machines for most of the work, even in developing countries. There are three basic steps in processing harvested rice: (1) clean-

Powerful machines called *combines, left,* are used to harvest rice in developed countries. Combines also thresh the grain as they harvest it.

Hulling rice separates the shell-like hulls from the grain. The machine shown above loosens the rice hulls but does not remove the bran coats from the kernels.

ing and hulling, (2) removing the bran layers, and (3) grading.

Cleaning and hulling. Cleaning removes dirt, straw, weeds, and other impurities from the rough rice. The cleaning equipment uses screens to sift out unwanted materials and fans to blow away lightweight debris.

After cleaning, the rice is placed in a machine called a *sheller* for hulling. In the sheller, the grains pass between rubber rollers or stone discs that loosen the hulls without breaking the kernels. The hulls are separated from the grain by suction. A screen then separates the hulled grain from any remaining unhulled rice. Some hulled rice may be packaged as brown rice. But most of it is processed into white rice. Rice may be treated by parboiling or other methods to improve its food value.

Removing the bran layers. After hulling, the brown rice passes through a series of machines that rub off its bran layers and embryo. The remaining endosperm becomes the white rice we eat. In many Asian countries, a single machine called a *huller mill* strips off both the hull and most of the bran. After milling, the kernels are packaged for sale. Most of the bran removed during milling is used in livestock feed.

Grading. Millers sort the processed rice into different grades for marketing. In most developed countries standards are set for grading rice. These grades are based on such qualities as the size of the kernels, the moisture content of the kernels, and the number of chalky or damaged kernels. In the United States, for example, these grades range from U.S. No. 1, for the highest quality rice, to U.S. No. 6, which is a lower quality rice. U.S. Sample is the lowest grade of rice.

History

No one knows exactly when or where rice originated. But it probably first grew wild and was gathered and eaten by people in Southeast Asia thousands of years ago. Archaeologists have found evidence that people cultivated rice for food by about 5000 B.C. in southern China and the northern part of Thailand, Laos, and Vietnam. From there, rice spread northward in China and to Japan and Korea; westward to India; and southward to Indonesia.

Traders and explorers carried rice from Asia to other parts of the world. Rice cultivation had spread to Persia (now Iran) and Syria by 300 B.C. Europeans first learned of rice from Greek soldiers who accompanied Alexander the Great's military expedition to India in the 320's B.C. But rice was not cultivated in Europe until the Moors of northwestern Africa conquered Spain about A.D. 700 and brought rice with them. Rice was brought from Spain to Italy several hundred years later and afterward spread to southeastern Europe. Spanish explorers introduced rice to the West Indies and South America on voyages during the 1400's, 1500's, and 1600's. Rice reached the American Colonies during the 1600's.

In 1960, government agencies and private foundations set up the International Rice Research Institute in the Philippines. The institute worked to improve rice production as part of a worldwide effort to increase food production in developing countries. This successful effort was an important part of what became known as the Green Revolution. In the 1960's, researchers at the institute developed new varieties of rice that produce more grain than older varieties, especially when fertilized. Traditional rice plants often grow so tall that they fall over and destroy their panicles. The new high-yield varieties have shorter, sturdier stalks and are less likely to topple. Since the 1960's, scientists have worked to develop varieties that can better resist diseases and insects and can grow without irrigation.

Today, farmers in some developing countries increasingly use machines for ploughing and other work once done by hand. Computers help some farmers plan production and control irrigation, especially in developed countries.

Scientific classification. Rice belongs to the grass family, Gramineae. Asian rice is *Oryza sativa*, and African rice is *O. glaberrima*.

See also **Agriculture** (picture: Intensive agriculture); **Grain weevil; Wild rice.**

Outline

I. The rice plant
- A. Structure
- B. Growth and reproduction

II. Uses of rice
- A. Food
- B. Other uses

III. Kinds of rice

IV. Where rice is grown

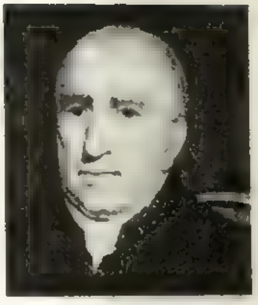
V. How rice is grown
- A. Preparing the ground
- B. Planting
- C. Controlling diseases and pests
- D. Harvesting

IV. How rice is processed
- A. Cleaning and hulling
- B. Removing the bran layers
- C. Grading

VII. History

Questions

Which two countries produce the most rice?
Why is brown rice more nutritious than white rice?
What are the four main parts of a rice plant?
How can farmers best protect rice crops from diseases and insects?
How do rice planting methods in developing countries differ from those in developed countries?
Why do rice farmers usually flood their fields?
What are some advantages of new varieties of rice?
Which part of a rice kernel is most often eaten?
How does the cultivation of lowland rice differ from that of upland rice?



Edmund Ignatius Rice

Rice, Edmund Ignatius (1762-1844), an Irish philanthropist and religious leader, was a pioneer of primary school education in Ireland. He founded the Irish Christian Brothers. This Roman Catholic charitable organization was set up in 1808 to educate the poor. Rice was born at Westcourt, in County Kilkenny. He moved to Waterford in 1779 and eventually became a respected businessman. The Irish Christian Brothers grew out of Rice's efforts to educate the poor at his own expense. He patterned the order on the work of St. Jean Baptiste de la Salle in France.

The turning point in Rice's life was the death of his wife in 1785. He turned increasingly to religion, finally retiring from business and devoting himself to good works. In 1803, he opened his first school for poor boys in Waterford. In 1820, Pope Pius VII formally licensed the new Congregation of the Brothers of the Christian Schools of Ireland. Rice, as Brother Ignatius, was elected its first superior-general. By the time he retired in 1838, the Christian Brothers had opened 22 schools in Ireland and England.

See also **Christian Brothers**.

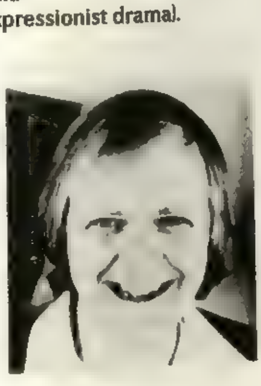
Rice, Elmer (1892-1967), was an American dramatist who championed moral, social, and personal freedom. His many plays reflect his belief that it is better to love than to hate, to question than to accept, to be free than to be bound.

Rice is best known for two plays. *The Adding Machine* (1923) is an expressionistic satire on the growing mechanization of man. Rice used distorted settings and nonrealistic acting to show the tortured mind of the chief character, Mr. Zero. *Street Scene* (1929), a Pulitzer Prize winner, gives a naturalistic picture of life in a crowded big-city block of flats. Rice's other plays include *Counsellor-at-Law* (1931); *We, the People* (1933); and *Dream Girl* (1945). Rice also wrote novels and an autobiography, *Minority Report* (1963).

Rice was born Elmer Leopold Reizenstein in New York City. He studied law, but became a playwright after his *On Trial* (1914) became a hit.

See also **Expressionism** (Expressionist drama).

Rice, Tim (1944-), a British writer and broadcaster, won fame for his collaboration with Andrew Lloyd Webber on the musicals *Joseph and the Amazing Technicolour Dreamcoat* (1968), *Jesus Christ, Superstar* (1970), and *Evita!* (1976). He also wrote the lyrics for Stephen Oliver's music in *Blondel* (1983) and *Cricket* (1986). He collaborated with Benny Andersson and Bjorn Ulvaeus on *Chess* (1984). His other writings include lyrics for popular songs and books about his songs. Timothy Miles Bindon Rice was born in Buckinghamshire, England. He was educated at Lancing College, Lancing, Sussex.



Tim Rice

Rice weevil. See **Grain weevil**.

Ricebird. See **Bobolink**.

Richard was the name of three English kings who ruled between 1189 and 1485. All three died violent deaths.

Richard I (1157-1199) ruled from 1189 to 1199. He is known in history as Richard the Lion-Hearted, or Richard Coeur de Lion. He was a son of Henry II, the first king of the Plantagenet dynasty (see **Plantagenet**). After Richard became king, he joined Philip Augustus of France in a crusade to the Holy Land. Richard captured Acre (now called Akko). He tried to retake Jerusalem, but failed.

During the crusade, Richard aroused the hatred of Leopold V, Duke of Austria. In 1192, while Richard was on his journey home, Leopold seized him. Leopold kept Richard in a castle on the Danube River as a prisoner of the Holy Roman emperor, Henry VI. It is said that while Richard lay in prison his favourite minstrel, Blondel, made himself known to his master by singing outside the castle. Richard was later taken to Henry, who released him in 1194 after a ransom was paid.

Detail of an engraving (1743) by George Vertue; The Newberry Library, Chicago

Richard I

Richard returned to England in 1194, but did not really rule. He left the government to the care of a minister and fought in a war with Philip Augustus of France. In 1199, Richard was killed during the siege of a French castle, and his brother John became king.

During his entire reign, Richard spent little more than six months in England, and he performed no real service for the good of his country. He was a brave and vigorous man who was sometimes cruel, but was often gallant and generous. Richard was a *troubadour* (lyric poet), and some of his songs have been preserved. See also **Flag** (picture: Historical flags of the world [Early English flags]).

Richard II (1367-1400) was 10 years old when he succeeded his grandfather, Edward III, as king. He was the son of Edward, the Black Prince, and a nephew of John of Gaunt, Duke of Lancaster (see **John of Gaunt**). From the beginning of Richard's reign, Gaunt was the real ruler. Gaunt taxed the people so heavily that a rebellion under Wat Tyler broke out in 1381 (see **Wat Tyler's Rebellion**). Richard

Detail of an illuminated manuscript (about 1389) by an unknown artist; St. John's College, Cambridge, England

Richard II

showed considerable spirit and courage in putting down the rebellion.

Richard was a tyrant. He was guilty of great extravagance and of playing favourites. Because of his conduct, he won the hatred of all classes. The breaking point came when he seized the estates of his cousin, Henry Bolingbroke, John of Gaunt's son, in an attempt to ruin the House of Lancaster. Bolingbroke rallied an army and in 1399 forced Richard from the throne. Bolingbroke then became King Henry IV (see **Henry** [IV] **of England**). Richard died in prison. He was probably murdered.

Richard III (1452-1485), Duke of Gloucester and brother of Edward IV, became the last Plantagenet king in 1483. His reign brought on the revolt that ended the Wars of the Roses (see **Wars of the Roses**).

National Portrait Gallery, London

Richard III

In the spring of 1483, Edward IV died, and his elder son became King Edward V at the age of 12. The young king was left in the care of Richard, who was named protector of the realm. The Woodvilles, the family of the young king's mother, attempted to seize power. In crushing their conspiracy, Richard found that he might himself become king and reached for the opportunity. He was crowned early in July 1483, after Parliament had declared him rightful king. Edward V and his younger brother Richard were put in the Tower of London. Some scholars believe that King Richard had the boys killed. But no proof of such a crime exists, and the fate of the youths is still a mystery.

Richard governed well, but the people grew tired of civil disturbances. Powerful Lancastrian nobles plotted against him. With their help, Henry Tudor, Earl of Richmond, of the House of Lancaster, invaded England from his exile in France. His forces won the Battle of Bosworth Field in 1485, killing Richard. Henry Tudor became king as Henry VII.

See also **Lancaster; Shakespeare, William** (Shakespeare's plays); **York.**

Richard the Lion-Hearted. See **Richard** (I).

Richards, Dickinson Woodruff, Jr. See **Nobel Prizes** (table: Nobel Prizes for physiology or medicine—1956).

Richards, Frank (1875-1961), was the pen name of Charles Hamilton, the English author of the "Billy Bunter" stories. He wrote more than 30 books about Billy Bunter, the fat boy of Greyfriars, a boarding school. Richards was born in Chiswick, London.

Richards, Sir Gordon (1904-1986), was the first British jockey to be knighted. He received the honour in 1953 for his services to horse racing. Richards was born in Oakengates, Shropshire. When he was 16 years old, he rode his first winner, Gaylord. During his career, Richards rode a record 4,870 winners out of a total of 21,834 rides. He won 14 classics and was champion jockey 26 times. In 1953, Richards won the Derby for the first time. He finally retired from horse racing in 1954.

Richards, I. A. (1893-1979), a British critic, published *The Meaning of Meaning* (1923) with C. K. Ogden. This book strongly influenced the semantic movement (see **Semantics**). It shows Richards' use of psychology in dealing with language. Richards became a leader in the attempt to make literary criticism scientific in *Principles of Literary Criticism* (1924), *Science and Poetry* (1925), *Practical Criticism* (1929), and *The Philosophy of Rhetoric* (1936). In 1932, he began working with Basic English, a form of English with an 850-word vocabulary. Ivor Armstrong Richards was born in Cheshire, England.

Richards, Viv (1952-), is one of the greatest, most exciting, and highest-scoring batsmen in the history of cricket. He was appointed captain of the West Indies team in 1985. Richards is a powerful right-handed batsman, a useful off-break bowler, and a fine fielder. Richards' test career began in 1976. He scored 291 runs off 386 balls in a test match against England in 1976. His fastest innings was 110 not out, scored off only 56 balls in St. John's, Antigua, in 1986. Richards scored his 100th first-class century in 1988.

Isaac Vivian Alexander Richards was born at St. John's, Antigua. He played for Leeward Islands from 1971 to 1972, and from 1986 to 1989. He played for Somerset, England, between 1974 and 1986. He also played for Queensland, Australia, in 1976-1977. He played for Glamorgan, Wales, from 1990 to 1993.

Richards Bay (pop. 23,328) is a town in Kwazulu-Natal on the northeastern coast of South Africa. During the 1980's, its population more than doubled compared with the 1980 census figure. For location, see **South Africa** (political map).

The town's deep water harbour handles more freight than all the other ports in South Africa. A wall across the lagoon preserves a natural area for pelicans, flamingoes, herons, and other water birds. The port was opened in 1976. The main export is coal, which arrives from coalfields in Eastern Transvaal and Kwazulu-Natal. Coal exports are more than 24 million metric tons a year. Richards Bay is one of the largest coal terminals in the world. The port was named after Rear Admiral Sir Frederick William Richards, commodore of the Cape of Good Hope Station of Britain's Royal Navy.

Richardson, Henry Handel (1870-1946), was the pen name of Ethel Florence Richardson Robertson, one of the most outstanding Australian novelists. She treated themes of universal interest at a time when nationalist themes were prevalent in Australian literature. She used carefully selected detail to build up convincing characters and scenes.

Her most successful work is *The Fortunes of Richard Mahony,* a trilogy consisting of *Australia Felix* (1917), *The Way Home* (1925), and *Ultima Thule* (1929). It tells the story of Richard Mahony, a man who is at odds with himself and his environment. It describes his rise to a position of prosperity and security as a doctor, his anguished search for

Henry Handel Richardson

meaning in his life, and his final breakdown. Richardson's first novel, *Maurice Guest* (1908), recreates the lives of music students in Leipzig, Germany. It describes a young musician's obsessive love for an Australian girl with romantic ideals. *The Getting of Wisdom* (1910) is a short, autobiographical novel.

Ethel Florence Richardson was born in Melbourne. She was the eldest daughter of Walter Lindesay Richardson, an Irish doctor. She was educated at the Presbyterian Ladies' College in Melbourne. At the age of 17, she went to Leipzig to study as a pianist. In 1895, she married J. G. Robertson, who later became professor of German at London University.

See also **Australian literature** (Modern novels).

Richardson, Henry Hobson (1838-1886), was the first American architect to achieve international fame. He dominated United States architecture during the 1870's and 1880's.

Richardson established the Romanesque Revival as a major architectural style. But he was chiefly interested in reworking Romanesque and other earlier styles to

Richardson's Glessner House shows the influence of Romanesque architecture in its massiveness and rough stone surface.

create new arrangements of forms and spaces. His most notable buildings are straightforward and massive, with surfaces of rough stone and closely fitted brick and shingles.

Richardson was born on a plantation near New Orleans, Louisiana. He first gained national prominence by winning the design competition for the Trinity Church in Boston, Massachusetts, in 1872.

See also **Architecture** (Early modern architecture in America).

Richardson, Sir Albert (1880-1964), became known as a traditional British architect and writer on architecture. He was responsible for housing estates in London, Bedfordshire, and Suffolk. He designed the Jockey Club, Newmarket; Ascot Royal Pavilion; Ripon Hall, at Oxford; and the Battle of Britain Chapel, in Westminster Abbey. Richardson was born in London.

Richardson, Sir Owen W. (1879-1959), won the Nobel Prize for physics in 1928 for his studies of *thermionic emission.* Many metals give off electrons when red-hot. The electrons constitute a current called a *thermionic current.* The equation that gives the thermionic current in terms of temperature for a given metal is now called *Richardson's law.* Richardson was born in Dewsbury, West Yorkshire, England. He studied at Cambridge.

Richardson, Sir Ralph (1902-1983), won international fame for his performances in a wide range of stage and film roles. He won acclaim on the stage for the title roles in Ibsen's *Peer Gynt,* Rostand's *Cyrano de Bergerac,* and Chekhov's *Uncle Vanya,* for the role of Bluntschli in Shaw's *Arms and the Man,* and for many Shakespearean characters. His films include *Anna Karenina, The Fallen Idol, The Heiress,* and *Lady Caroline Lamb.*

Richardson was born in Cheltenham, Gloucestershire, England. He made his first stage appearance in 1921. He was knighted in 1947.

Richardson, Samuel (1689-1761), an English writer, is considered one of the founding fathers of the novel. He wrote three novels: *Pamela; or, Virtue Rewarded* (1740), *Clarissa; or, The History of a Young Lady* (1747-1748), and *Sir Charles Grandison* (1753-1754). These works are too long to be much read today, but their influence has been enormous.

Richardson's books brought various important, and in some ways new, elements to the novel. Each of his novels has a genuinely unified plot rather than disconnected episodes. The characters maintain a consistent point of view, without interference by the author. The works established the theme of courtship leading to marriage as a basic plot of the novel.

All three novels are written in the form of letters. Indeed, the idea for the form of *Pamela* originated from a manual of model letters written by Richardson. *Pamela* was published anonymously and was a sensational success. All the novels have a breathless quality that sweeps the reader along from letter to letter to see what happens next.

It is easy to mock the somewhat dubious, often priggish morality of Richardson's novels. Indeed, *Pamela* inspired several witty parodies by writers of his time. Nevertheless, Richardson set the novel firmly in what became its main direction: a detailed description of real people in common situations of domestic life.

In particular, Richardson's novels treat women's concern for security, marriage, and a proper social role. This reflects how, with the rise of the new middle class, women with conscious individual identities and problems were coming to the forefront. This tendency has grown since Richardson's time, and in him, as in many later novelists, women have found a sympathetic and sensitive spokesman.

Richardson was born in Derbyshire. He started his own printing business in 1719, and later became one of London's most successful publishers.

Richelieu, Cardinal (1585-1642), was one of the ablest of French statesmen. For more than 18 years, he was the actual ruler of France. He strengthened the French monarchy.

Richelieu was born in Paris. His real name was Armand Jean du Plessis. He took the name Richelieu from the name of his family's estate. Richelieu came from a

family of the minor nobility, which for many years had served in the armies of France. His father fought with distinction in the religious wars. King Henry III rewarded the father by offering the office of bishop of Luçon to his eldest son. Richelieu, the third son, accepted the position to keep the bishop's income in the family.

Cardinal Richelieu

Becomes bishop. Richelieu was more than five years under the age required for his position as bishop when he took the post in 1606. The next year, he was consecrated by the pope. As bishop, Richelieu proved himself able and energetic. But he was extremely ambitious and soon became impatient for higher office. In 1614, he was elected to represent the clergy of Poitou in the *States-General* (Parliament) of France. His great charm and tact soon made him a trusted friend of Marie de Médicis, the mother of King Louis XIII.

By 1616, he had become a member of the Royal Council of Louis XIII. But this appointment lasted only a short time. King Louis distrusted his mother's power and began to fear for his throne. He arranged the murder of his prime minister, the Marquis d'Ancre, and exiled Richelieu and the queen mother in 1617.

Rise to power in France. Pope Gregory XV made Richelieu a cardinal in 1622. In 1624 he regained a place in the king's council. He served with great skill and ability and soon became the leading influence in the French government. He ruled France from 1624 to 1642 in the interests of Louis XIII.

Richelieu first sought to make a friendly alliance with England. He arranged the marriage of the Prince of Wales and Henrietta Maria, the sister of Louis XIII. He then turned to the situation in France. He wanted to make the royal power supreme throughout the country. He determined to humble the proud feudal nobles of France and to put down the rebellious Huguenots.

Religious wars. Richelieu was not himself intolerant in religious matters. He made no attempt to take freedom of worship away from the Huguenots, and made war upon them only as enemies of the king. He led the royal army in person at the siege of La Rochelle. This Huguenot stronghold, aided by the English, held out for 14 months, but surrendered in October 1628. Richelieu destroyed the political privileges which the Huguenots had received by the Edict of Nantes. But he did not interfere with their right to worship.

Richelieu then turned his attention to the nobles. He considered their independence the greatest obstacle to a centralized state in which the king held all the power. In 1626, he called out the army to destroy all fortified castles not needed for defence against invasion. His action weakened the nobility.

His influence in Europe. Richelieu's greatest interest was in foreign affairs. He wanted to make France strong at home and abroad. When he came to power, Europe was struggling in the Thirty Years' War. He saw an opportunity for France in the confusion. He dreamed of making France "the heart of all Christian states," both Protestant and Catholic.

To thwart the powerful Habsburg Empire, Richelieu decided to support the Netherlands and the various German princes in their attack on Austria from the north. He also planned to help the Italians attack the Habsburgs and the Spaniards from the south. But troubles inside France delayed Richelieu's plans.

From 1628 to 1631, Richelieu fought both Spain and Savoy over the French claim to the duchy of Mantua. Under his direction, Louis XIII led 36,000 men across the Alps and established Charles Gonzaga, Duke of Nevers, as the ruler of Mantua. To keep Sweden at war with the Habsburgs, Richelieu paid Sweden a considerable fee and promised to subsidize her army for six years, or until a general peace was made.

Richelieu thus saved France the enormous expense of a war, but he accomplished the purpose of a war by paying Sweden to fight his enemy. He did not live to see the full results of his plans to humble Spain and Austria. But when he died in 1642, France had won parts of Alsace and Lorraine.

Richelieu was a man of learning and wanted to be a great writer. He wrote many works. But his greatest contribution to literature was his support and protection of literary people, and the founding of the French Academy in 1635.

Related articles in *World Book* include:

Codes and ciphers (History)	French Academy	Mazarin, Jules Cardinal
Diplomacy (History)	Huguenots	Sorbonne
Estates-General	Louis (XIII)	Thirty Years' War

Richelieu River is a Canadian stream that flows through some of Quebec's most beautiful valleys. The Richelieu rises in Lake Champlain, near the Quebec-Vermont border. It flows north for 130 kilometres and meets the St. Lawrence River at Sorel, between Montreal and Trois Rivières. Ships travel along the river from Sorel south to Chambly. The Richelieu has two canals—one at St. Ours, south of Sorel, and the other at Chambly. It is a transportation artery, but is better known as a place for boating. It was named after Cardinal Richelieu, a French statesman.

Richler, Mordecai (1931-), is a Canadian novelist. As a boy, Richler lived in a poor Jewish district of Montreal, where he was born. His experiences there provided the background for *Son of a Smaller Hero* (1955) and *The Apprenticeship of Duddy Kravitz* (1959).

From 1954 to 1972, Richler lived mainly in England. *A Choice of Enemies* (1957) is set in London. In *Cocksure* (1968) and *St. Urbain's Horseman* (1971), Richler wrote about Canadians living in Europe. These novels, and *Joshua Then and Now* (1980), are character studies that satirize sophisticated, urban society. He has also written short stories, film and TV scripts, and a children's book called *Jacob Two-Two Meets the Hooded Fang* (1975). The best of his essays and articles were published as *Notes on an Endangered Species and Others* (1974). He described his impressions of Canada in *Home Sweet Home* (1984).

Richmond, Virginia (pop. 203,056; met. area pop. 865,640), is the state capital and a major commercial, cultural, educational, and historical centre. It ranks as Virginia's third most populous city. Only Norfolk and

Virginia Beach have more people. Richmond is a leading producer of cigarettes and other tobacco products. It was the capital of the Confederate States of America during most of the Civil War (1861-1865). Richmond lies on the James River, in east-central Virginia.

Richmond upon Thames (pop. 154,600) is a borough within the Greater London area, England. It includes the former boroughs of Barnes, Richmond, and Twickenham. Richmond upon Thames is a popular riverside resort on the River Thames. It is also a residential district. The remains of the Tudor royal palace where Queen Elizabeth I died in 1603 lie in the borough. Richmond upon Thames also has a number of Queen Anne and Georgian houses still standing, including Asgill House, Maids of Honour Row, Trumpeter's House, and Wick House. Most of Richmond Park is in the borough.

Richmondshire (pop. 43,800) is a local government district in North Yorkshire, England. Much of the district lies high above sea level. It contains almost all of Swaledale and Wensleydale and part of the Yorkshire Dales National Park. Richmond, the administrative centre, is a market town. It has a Norman castle, and a Georgian theatre, built in the 1700's, that was restored in 1962. Other towns and villages include Brompton-on-Swale, Hawes, Leyburn, Middleham, and Scorton. Richmondshire has cattle and sheep rearing and produces cheese.

See also **Yorkshire.**

Richter, Burton. See **Nobel Prizes** (table: Nobel Prizes for physics—1976).

Richter magnitude is a number that indicates the strength of an earthquake. Scientists calculate Richter magnitude by using information obtained from a *seismograph,* an instrument that records an earthquake's ground motion. Charles F. Richter, an American *seismologist* (scientist who studies earthquakes), developed this system of measuring earthquakes in 1935. The system is sometimes called the *Richter scale.*

The highest Richter magnitude ever recorded is 8.9—recorded in the Pacific Ocean near the Colombia-Ecuador border in 1906, and again in Japan in 1933. This magnitude was calculated on the basis of instruments that were in use at the time. The Mexico City earthquake of 1985 measured 8.1.

More than 1,000 earthquakes with a magnitude of at least 2 occur daily. But seismologists consider earthquakes of magnitude 5 or less as minor because few cause serious damage. An earthquake of magnitude 7 or more can cause great damage and kill many people if the shocks are centred in a populated area.

Each number on the Richter scale represents an earthquake 10 times as strong as one of the next lower magnitude. For example, an earthquake of magnitude 7 is 10 times as strong as one of magnitude 6.

Although each earthquake has only one magnitude, its damage varies from place to place. Seismologists use various other scales to measure the damage of an earthquake. For example, the *Modified Mercalli Intensity Scale* (M.M.) classifies earthquakes into 12 categories ranging from those barely felt to ones that cause tremendous damage. The Mexico City earthquake of 1985, in which 7,200 people were killed and thousands more were injured, had an M.M. intensity of VIII to IX.

See also **Earthquake; Seismograph; Seismology.**

Richthofen, Manfred von. See **War aces.**

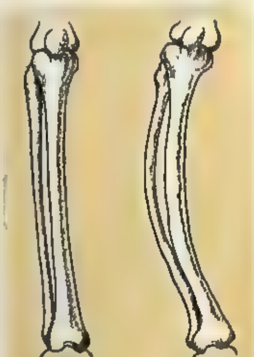
Rickenbacker, Eddie (1890-1973), was the leading United States air ace in World War I (1914-1918). He shot down 22 enemy planes and 4 balloons. In 1938, he became president of Eastern Airlines. He resigned in 1959, but stayed on as chairman of the board of directors until 1963.

Edward Vernon Rickenbacker was born in Columbus, Ohio. He was forced to leave school at the age of 13 when his father died. He studied by taking correspondence courses. One of his first successes was as a car mechanic and racing driver. After winning an international reputation in car racing, he enlisted in the Army in 1917. He served as a staff driver and as an engineering officer before becoming a pilot.

After World War I, Rickenbacker worked with several car firms and owned the Indianapolis Speedway for 18 years. As president of Eastern Airlines for 21 years, he led the company to prosperity.

On a World War II inspection trip for Secretary of War Henry Stimson in 1942, Rickenbacker and seven others were forced down in the Pacific about 970 kilometres north of Samoa. They were rescued after drifting for 24 days on rubber rafts.

Rickets is a bone disease that occurs mostly in children. It may be caused by a lack of calcium, phosphate, or vitamin D. Rickets also may be caused by the inability of the body to use those substances properly. In rickets, the bones are so soft that they bend into abnormal shapes and may develop bumps called *knobs.* Rickets results in conditions called rosary ribs, knobbed forehead, and funnel chest. As the child grows, bones harden, but the abnormal shape usually remains. In severe rickets, the bones may be so deformed that a child's normal height is greatly reduced. Some symptoms of rickets are sweating, weakness, pain in the bones, general body tenderness, and misshapen bones.



Normal lower leg bones — Lower leg bones affected by rickets

Eating foods that are rich in calcium and vitamin D usually prevents rickets. Calcium can be obtained by drinking milk and eating green vegetables. The best sources of vitamin D include vitamin-D enriched milk, sunlight, and fish oils.

Rickets in children usually can be stopped by supplying them with plenty of vitamin D and calcium. A disease similar to rickets sometimes occurs in adults and is called *osteomalacia.*

See also **Vitamin** (Vitamin D).

Rickettsia is any of a group of microorganisms that cause certain infectious diseases in human beings. Rickettsiae were once classified as viruses, but are now usually regarded as a special kind of bacterium. They differ from most bacteria in two major ways. They are smaller, and, like viruses, they cannot reproduce outside of living cells.

Rickettsiae live primarily in the cells of certain insects and other arthropods, such as mites and ticks. A few

species can infect human cells and cause such diseases as epidemic typhus, Rocky Mountain spotted fever, scrub typhus, and Q fever.

Epidemic typhus is spread among people by the bite of infected body lice. This disease occurs in the colder regions of the world, particularly those where people have poor sanitary facilities. The rickettsia that causes Rocky Mountain spotted fever lives in ticks and wild rodents and is spread to people by tick bites. This disease occurs most frequently in the Southeastern United States. Scrub typhus is common in Southeast Asia, northern Australia, and Japan. Rodents and chigger mites carry the rickettsia that causes this disease, and it is spread to people by mites.

Unlike other rickettsiae, the Q-fever organism infects people by being inhaled. Q fever is common in many livestock raising regions. Cattle and sheep that are bitten by infected ticks pass Q-fever rickettsiae in their urine and in the fluids lost while giving birth. The rickettsiae may infect people who inhale dust from livestock pens.

The symptoms of rickettsial diseases include chills, fever, headaches, and rashes. Untreated rickettsial diseases—particularly epidemic typhus and Rocky Mountain spotted fever—are often fatal. However, these diseases can be treated effectively with antibiotics. Rickettsiae were named after Howard Taylor Ricketts, an American pathologist who first identified the organisms in 1909.

Rickover, Hyman George (1900-1986), an American naval officer, pioneered in developing the *Nautilus,* the first nuclear-powered submarine. In 1965, he received the Enrico Fermi Medal, the highest United States atomic science award. Rickover wrote *Education and Freedom* (1959), in which he stated his views on education.

In 1947, Rickover became head of the Naval Reactors Branch of the U.S. Atomic Energy Commission. He also served as head of the Nuclear Power Division of the U.S. Navy. He was promoted to the rank of vice-admiral in 1959. Rickover reached compulsory retirement age in 1964, but his active duty was extended. In 1973, he was promoted to the rank of admiral. He continued to serve in the Navy's nuclear propulsion programme until his retirement in 1982. Rickover was born in Warsaw, Poland, and went to the United States with his family when he was 4 years old.

Ricksha. See Jinrikisha.

Riddell, Elizabeth (1910-   ), a New Zealand poet and journalist, worked in Australia, Britain, the United States, and Europe as a feature writer and war correspondent. In the course of her work, Riddell travelled widely. Her poetry has appeared in three collections—*The Untrammelled* (1940), *Poems* (1948), and *Forbears* (1961).

Following a poetically unproductive interval in the late 1960's and the 1970's, she began again to write, and was published again in the 1980's. Her poetry has been described as "controlled, spare, frequently witty, and lightly lyrical." In 1986, she received the award of Literary Critic of the Year from the National Book Council. Elizabeth Richmond Riddell was born in New Zealand.

Riddle is a question or statement that contains a deliberately hidden meaning. Riddles today are usually meant to be amusing. They often take the form of a *conundrum,* which is a kind of riddle that depends on puns. A typical riddle of this type is: "What has four wheels and flies?" The correct answer, "A rubbish truck," makes sense when we realize that the word *flies* has two meanings.

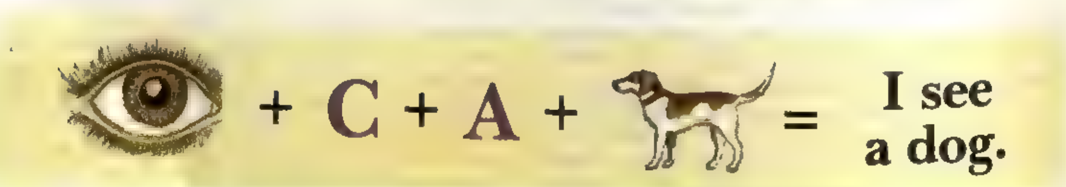
Another popular type of riddle depends on possible but unexpected assumptions in a given question. The answer to the riddle, "Where does an elephant go when he wants to lie down?" is "Anywhere he pleases." That answer is both humorous and surprising because the question seems to concern the habits of elephants, but it is really about the intimidating size of elephants.

For many centuries, the riddle was often regarded as a kind of coded message that came from divine inspiration. People believed the message could be understood only by persons equipped with special knowledge. In ancient Greece, priests and priestesses called *oracles* frequently expressed their messages in the form of riddles (see **Oracle**). The most celebrated riddle in Greek mythology was asked of the citizens of Thebes by the Sphinx: "What has one voice and becomes four-footed, two-footed, and three-footed?" The hero Oedipus solved the riddle. He correctly answered, "Man, who crawls on all fours as a baby, then walks on two legs as an adult, and finally needs a cane in old age."

During the Middle Ages, poets in Europe seem to have particularly enjoyed composing riddles. The so-called *Exeter Book* contains nearly 100 examples of riddles. They were written in an early form of English called Old English, probably in the early 700's. These riddles dealt with such subjects as storms, ships, beer, books, and falcons. The answers to some of these riddles are obvious, but other riddles are extremely difficult to understand. However, they are valuable for the insights they provide into the way people of that period regarded events of nature and everyday life.

Collections of riddles were among the first books ever printed for popular entertainment. A book of riddles called *Amusing Questions* was published in England in 1511 by a printer called Wynkyn de Worde. Many standard nursery rhymes, such as "Humpty Dumpty," are actually riddles that were invented centuries ago.

See also **Rebus; Nursery rhyme** (Rhyming riddles).



A rebus is a riddle that uses letters and pictures to indicate words.

Riddle of the Sphinx. See **Riddle; Sphinx.**

Rideal, Sir Eric Keightley (1890-1974), a British chemist, carried out research into surface chemistry, colloids, and the properties and effects of catalysts. He devised a method of measuring the *germicidal* (germ-killing) powers of disinfectants. He was born in London and studied at Cambridge and at Bonn, in Germany.

Riding. See **Horse** (How to ride).

Ridings. See **Tipperary; Yorkshire.**

Ridley, John (1806-1887), was the inventor of a reaping machine that reduced harvesting costs and revolutionized the Australian wheat industry. Using the machine, farmers could reap up to 5 hectares of wheat a day.

John Ridley

Ridley was born in Durham, England. He emigrated to South Australia in 1839 and built a flour mill near Adelaide. He invented his machine, called a *stripper,* in 1843. Similar machines were soon in use throughout Australia. But Ridley declined to patent his invention and refused to profit from it. In 1853, he returned to Britain.

Ridley, Nicholas (1500?-1555), an English bishop, was a martyr of the Protestant Reformation. Many regarded him as the master spirit among the English reformers. He helped compile the first Book of Common Prayer of 1549, and the Forty-Two Articles of Religion in 1553. The Forty-Two Articles later served as the basis for the Thirty-Nine Articles (see **Thirty-Nine Articles**). Ridley supported Lady Jane Grey's unsuccessful claim to the throne, and in 1553 Queen Mary imprisoned him in the Tower of London. In 1554 Ridley was condemned for heresy, and the following year he was burnt at the stake at Oxford. Hugh Latimer, Protestant bishop of Worcester, was executed at the same time (see **Latimer, Hugh**).

Ridley was born in Northumberland and graduated from Cambridge University. In 1547 he became bishop of Rochester, and in 1550, bishop of London. See also **United Kingdom, History of the** (picture: Martyrdom of Protestants).

Riemann, Georg Friedrich. See **Fourth dimension.**

Riemenschneider, Tilman (1460?-1531), was one of the best-known sculptors of his day in Germany. Riemenschneider carved in both stone and wood. Most of his sculpture is concerned with religious subjects. Riemenschneider's work is noted for its quiet religious feeling. His major sculpture is also known for its accurate portrayal of the subject's physical appearance, whether the subject is a person or an object.

Riemenschneider was born in Thuringia. He studied his trade in several German cities before settling in Würzburg. He spent most of his life there, becoming a prominent citizen and a member of the Würzburg city council.

Rienzi, Cola di (1313?-1354), was a famous Italian patriot. His career shows how power can turn a freedom-loving patriot into a tyrant.

Rienzi was born in Rome, where he received a good education and became a notary. The way the nobles of his time oppressed the common people made him sick at heart, and the nobles hated and feared him. In 1347, he became powerful enough to call a meeting of the people on Capitol Hill to demand a new government. Soon he became a *tribune,* or defender of the people, and received the powers of a dictator.

Rienzi ruled wisely for a time, but he began to want more power. He became unpopular, and the people lost confidence in him. After ruling for seven months, he fled to Naples. There, Emperor Charles IV imprisoned him. In 1354, Rienzi was released and returned to Rome. The people welcomed him, and he regained his lost power. But he again acted with the cruelty of a tyrant. He was killed while trying to put down a riot.

Rifkind, Malcolm (1946-), a Conservative politician, became the United Kingdom's foreign secretary in 1995. He had been secretary of state for defence from 1992 to 1995. Before that, he was minister of transport from 1990 to 1992, and secretary of state for Scotland from 1986 to 1990.

Rifkind was educated at Edinburgh University, and lectured at the University of Rhodesia from 1967 to 1968. He was first elected to Parliament, representing Edinburgh Pentlands, in 1974.

Nicholas Ridley was burnt at the stake in 1555. The Martyrs Memorial, *above,* marks the place in Oxford, England, where Ridley and Hugh Latimer were executed for their Protestant faith during the reign of Roman Catholic queen Mary Tudor.

Rifle is a gun that is held against the shoulder when firing. Soldiers use rifles in battle. People also use rifles to hunt game and to compete in shooting matches.

Military rifles and sporting rifles differ greatly. Military rifles are ruggedly built and are designed to work under the harshest conditions. Most military rifles are semiautomatic or automatic. An automatic rifle can fire bullets rapidly one after another with one squeeze of the trigger. Most hunting and target rifles are operated by hand after each firing and are designed for beauty as well as accuracy.

The parts of a rifle

All rifles have four basic parts: (1) the barrel, (2) the stock, (3) the action, and (4) the sights.

The *barrel* is a strong steel tube with spiral grooves called *rifling* cut along the inside. The front end of the barrel is called the *muzzle,* and the rear end is the *breech.*

The *stock* of a rifle helps keep the rifle steady when firing. The butt of the stock is placed against the shoulder when firing. The front end extends under the barrel. Stocks of military rifles are made of wood, plastic, or fibreglass. Many sporting rifles have stocks made of expensive wood with decorative or grip-aiding carving called *checkering.*

The *action* is the basic machinery of the rifle. The action includes the parts that feed a cartridge into the firing chamber, fire the bullet, and eject the used cartridge.

The *sights* are used to aim the rifle. When aimed properly, the rear sight, the front sight, and the target should be in alignment. Many sporting rifles have *telescopic sights* that make distant targets appear closer. On military rifles, telescopic sights are used only for sniping.

How a rifle works

A rifle is ready to fire when a cartridge has been fed into the *firing chamber.* Then the rifle is aimed and the trigger squeezed. The *hammer* or *firing pin* strikes the rear end of the cartridge and ignites the *primer.* The primer in turn ignites the propellant powder in the cartridge. The powder burns rapidly, creating pressure that drives the bullet down the barrel.

The rifling in the barrel makes the bullet spin. Without spin, a bullet will not stay pointed forward in flight, but will tumble over and over. The spinning motion increases the accuracy of a bullet.

Kinds of rifles

Rifles are classified by the type of action (manually operated, automatic, or semiautomatic); the name of the designer or manufacturer (for example, Remington or Winchester); or the *calibre.* The calibre may refer to the inside diameter of the barrel or the diameter of the bullet used in the rifle. The calibre is measured in *millimetres* or in decimal fractions of an inch.

There are three kinds of repeating rifles with hand-operated actions—*bolt-action, lever-action,* and *slide-action.* These rifles have *magazines* (cartridge holders) that feed cartridges into the firing chamber. The action on two other kinds of rifles—*semiautomatic* and *automatic*—is operated by some of the forces caused by the explosion of a cartridge in the firing chamber.

Bolt-action rifles have an action that resembles a bolt used to lock a door. When the bolt on the rifle is pulled back, the used cartridge is ejected and the hammer is cocked. When the bolt is moved forward, it pushes a new cartridge into the firing chamber.

Lever-action rifles are loaded by moving a lever under the breech down and back up. The down movement ejects the used cartridge and cocks the hammer. The up movement inserts a new cartridge into the firing chamber.

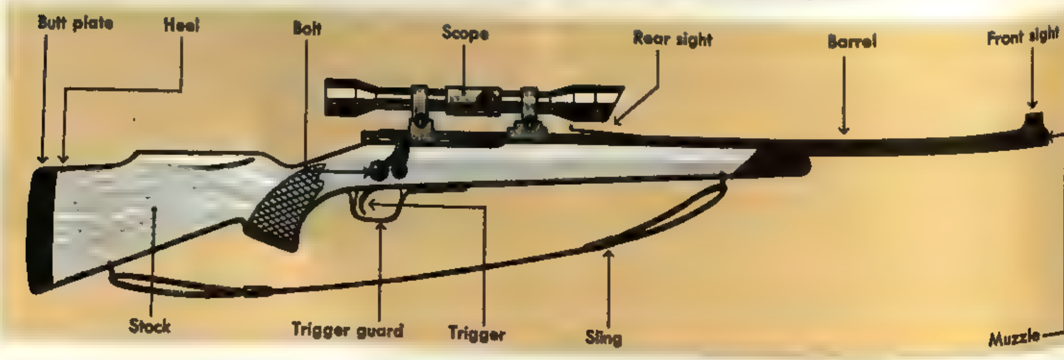
Slide-action rifles, also called *pump-action rifles,* are loaded with a back-and-forth movement of a rod and handle beneath the front part of the barrel. When the handle is pulled back, the breech opens and the used cartridge is ejected. A live cartridge is inserted when the handle is pushed forward.

Automatic and semiautomatic rifles are used mainly by soldiers and police officers. When a rifle is fired, gas is formed by the burning powder in the firing chamber. The expanding gas drives the bullet out of the barrel. When a cartridge is fired, a fresh cartridge is moved out of the magazine into the firing chamber, and the firing mechanism is cocked. A completely automatic rifle fires one bullet after another when its trigger is held back.

Rifle cartridges

Rifle cartridges are enclosed in a *casing* (metal covering) made of brass or steel. Cartridges vary in size ac-

Parts of a rifle A bolt-action repeating rifle can be fitted with a small telescope called a *scope* to make distant targets appear closer. The bolt-action rifle is the most popular kind of repeating rifle.



cording to the calibre of the rifle. The names of some cartridges include the year the cartridge was put into use. The .30-06 is a .30-calibre cartridge chosen for use by the U.S. Army in 1906. The classification of some cartridges includes the calibre and *velocity* (speed) of the bullet. The bullet from a .250-3000 cartridge has a velocity of 910 metres (3000 feet) per second.

History

Modern rifles developed from the crude, muzzle-loading firearms of the 1400's. Rifling of barrels was invented in Europe about 1500. *Smooth-bore* firearms (weapons without rifling) could not be depended on to hit targets more than 100 steps away.

The jaeger rifle of central and northern Europe was the first accurate rifle. The jaeger was developed about 1665. German immigrants brought jaegers to Pennsylvania in the early 1700's and gave them new features, including longer barrels. The Pennsylvania-made Kentucky rifle developed from the jaeger. Some Kentucky rifles were used during the American Revolution (1775-1783).

Rifles used round bullets until the 1850's, when the more accurate Minié bullets became popular. Minié bullets had hollow bases and pointed tips.

Famous rifles Early rifles were used for hunting, target shooting, and warfare. The same type of rifle was used for all three purposes. Today's automatic and semiautomatic rifles are used mainly by the military, and repeating rifles with hand-operated actions are used for hunting and target shooting.

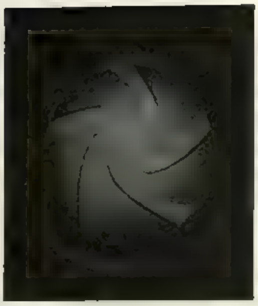
The flintlock rifle had to be reloaded through the muzzle after each firing. This British military rifle—the Baker—was used during the first half of the 1800's.

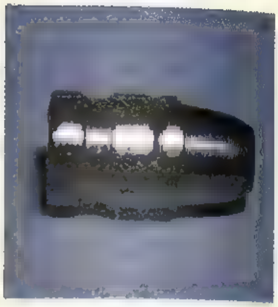
The Sharps buffalo rifle was a long-range hunting rifle popular during the 1870's and 1880's. It could be fired by lightly touching one trigger after pulling the other.

The Colt revolving rifle could be fired five or six times without reloading, but was hazardous to the shooter. The manufacturer made models for military and sporting use.

The Mauser 1898 was a bolt-action military rifle. It was the model for the American Springfield rifle used during World War I and many other military and sporting rifles.

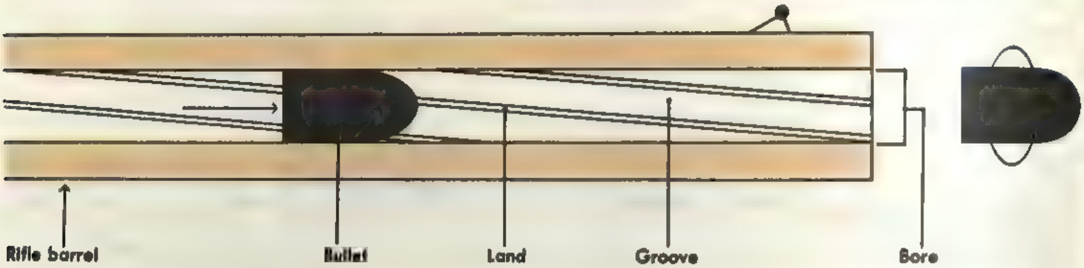
The M16A2 rifle is capable of firing one shot at a time, or 3 bullets in less than a second. The M16A2 is the official rifle of the United States armed forces.





How rifling works

Rifling is the wide spiral grooves that are cut along the *bore* (inside) of a rifle barrel, *right.* The thin, slightly raised bore surfaces are called *lands.* When the rifle is fired, the grooves give a spinning motion to the bullet. This spinning motion makes the bullet stay on course in flight and increases its range. Friction from the lands marks the bullet, *far right.*



Improvements of the late 1800's included repeating rifles, smokeless explosive powder, and *jacketed* bullets, which have a metal cover over a lead or steel core.

Related articles in *World Book* include:

Ammunition	Cartridge	Gunpowder	Shotgun
Bullet	Firearm	Musket	Sniperscope
Carbine	Garand rifle		

Rifleman is the name of a wren found throughout New Zealand. It is a stocky little bird that grows up to 8 centimetres long. The rifleman has greenish-brown upper parts and light coloured underparts. Its beak is sharp and slender, and is used to prise spiders and insects from crevices in trees. The rifleman forages for food on the large branches and trunks of trees, especially those of southern beeches.

The rifleman has interesting breeding habits. The male bird does most of the nest building. It also feeds the female before and during egg laying. The female rifleman lays five eggs. The male does most of the rearing of the chicks. Sometimes, the male is helped by other single birds that have not mated that season.

Scientific classification. The rifleman belongs to the family Xenicidae. It is *Acanthisitta chloris.*

Rift Valley. See **Great Rift Valley.**

Riga (pop. 875,000) is the capital and largest city of Latvia. Riga is an important shipping centre, and it accounts for more than half of Latvia's industrial production. It also has been the cultural and political centre of Latvia for hundreds of years. The city lies at the south end of the Gulf of Riga, where the Western Dvina (Daugava) River empties into the gulf. For location, see **Latvia** (map). In the city, modern housing complexes rise around beautiful churches and merchant houses that date from the Middle Ages.

Riga was founded by German crusaders in 1201. Latvia became an independent nation in 1918, with Riga as its capital. In 1940, the Soviet Union seized Latvia and made it part of the Soviet Union. In 1991, Latvia broke away from the Soviet Union and became an independent nation again.

Rigel is a blue-white star in the southwest corner of the constellation Orion. Rigel is one of the brightest stars in the galaxy, perhaps 50,000 times brighter than the sun. Rigel is about 50 times larger than the sun and measures at least 64 million kilometres across. It is over 900 light-years away (see **Light-year**).

Rigging. See **Sailing** (Rigging).

Right-hand rule. See **Electric motor** (Basic principles).

Right of possession. See **Title.**

Right of search. Under international law, a nation at war has the right to visit and search merchant ships of neutral nations. The search must be carried out by the officers of a warship. The purposes are to determine the true nationality of the vessel, and to find out whether the vessel is engaged in unneutral service or in carrying contraband of war (see **Contraband**). In peacetime, the right of search may be exercised to enforce revenue laws or prevent piracy.

In making the search, the ship's papers are first examined. These papers name the ship, its master, or captain, the port it sailed from, and the port for which it is bound. The papers should describe the cargo and certify that the officers have met the customs regulations of the country from which the ship has sailed.

If the papers are correct, the search usually ends. But if suspicion is aroused, the cargo may be examined. Officers who refuse to stop their ship and allow it to be searched run the risk of having both ship and cargo confiscated. The Hague Peace Conference of 1907 and the London Conference of 1909 tried to set limits to the right of search. Conference members agreed that the mail of neutral nations should be free from search.

During the 1920's, some countries agreed to extend their territorial limits to the number of nautical miles that could be covered in one hour's sailing from their coasts. These agreements made it easier to search for smuggled articles, and they remain in force. For other purposes, the limits are 3 to 12 nautical miles, depending on the kind of search.

Right of way is the term used in Australia, New Zealand, and the United Kingdom for a right of passage over private land or along a river. A landowner may acquire a right of way *by necessity* over a neighbour's property if the landowner has to pass over it to get to his or her own property. A number of people may acquire a right of way over private land as an *easement* (see **Easement**). The public may acquire a right of way in one of three ways. Landowners may expressly dedicate a way across their land as a public right of way. Parliament may create a right of way by statute. The public may acquire a right of way by using a road, pathway, or river uninterruptedly for 20 years as if they had a right to do so. A landowner who is willing to let people use a way but does not wish to create a public right of way must make this fact clear by erecting a notice nearby or by closing the way for one day a year.

Right whale. See **Whale** (Right whales; The early days of whaling; pictures).

Right wing refers to a conservative, traditional group or political party. In some legislative bodies, the conservatives sit to the right of the speaker. Radical and liberal groups form the *left wing*, with middle-of-the-road groups making up the *centre*. This custom originated with the French National Assembly of 1789. In that assembly, nobles took the honoured seats to the king's right. See also **Conservatism**.

Rights, Bill of. See **Bill of rights.**

Rights of Man, Declaration of the, is a French document that sets forth the principles of human liberty and the rights of individuals. The document's full name is the Declaration of the Rights of Man and of the Citizen. The first two articles of the declaration state that all people are free and equal in rights, which include "liberty, property, security, and resistance to oppression." The other 15 articles of the declaration concern both the limitations of government and the rights and obligations of citizens.

The French National Assembly adopted the declaration on Aug. 26, 1789, during the French Revolution. The refusal of King Louis XVI to approve the declaration helped bring about increased revolutionary activity in October 1789.

The writers of the declaration were influenced partly by the United States Declaration of Independence, but above all by the circumstances of the revolution. The document was intended to be the statement of principle for the new regime.

Riis, Jacob August (1849-1914), was an American journalist, photographer, and social reformer. During the late 1800's and early 1900's, he helped improve living conditions in New York City slums by exposing them to the public through his writings and photographs. Photographs taken by Riis were among the first to appear in newspapers.

Riis was born in Ribe, Denmark. He emigrated to the United States in 1870. In 1877, Riis became a reporter for the *New York Tribune,* and in 1890, he moved to the *New York Evening Sun.* As a reporter, Riis worked for improvements in education, housing, and law enforcement and for child-labour laws and playground construction. In 1888, he helped bring about the elimination of a notorious New York City slum district called Mulberry Bend.

Besides writing for newspapers, Riis wrote 12 books. They include *How the Other Half Lives* (1890), *The Children of the Poor* (1892), and *The Battle with the Slum* (1902). *The Making of an American* (1901), tells the story of his emigration to the United States.

See also **Playground** (with picture); **United States, History of the** (picture: The lives of the poor and the rich).

Riley, James Whitcomb (1849-1916), an American, won fame as the *Hoosier Poet.* He wrote much verse in pure English, but his most popular poems were those he wrote in the dialect of his home state of Indiana. They include "When the Frost Is on the Punkin'," "Out to Aunt Mary's," and "Little Orphan Annie." These works are characterized by light humour, pathos, and sentiment. Riley's poems were published in a number of collections, including *The Old Swimmin'-Hole and 'Leven More Poems* (1883), *Rhymes of Childhood* (1890), *Poems Here at Home* (1893), and *Book of Joyous Children* (1902).

Riley, the son of a lawyer, was born in Greenfield, Indiana. He left home after receiving a grammar school education, and worked for a time as a sign painter. For a short period, he travelled with a medicine show. Riley had heard the dialect and learned the manners of the country folk of Indiana from his childhood, and he began to write poems about them.

Riley joined the *Indianapolis Journal* in 1877. He made his home in Indianapolis. He began to contribute poems to several papers under the name "Benj. F. Johnson of Boone." He became a celebrated platform reader and appeared throughout the United States, often with the humorist Bill Nye.

Rilke, Rainer Maria (1875-1926), was an important lyric poet in German literature and a major representative of the symbolism movement. His poems are characterized by richness of imagery and melody and fine shades of meaning.

Rilke's cycle of poems *The Book of Hours* (1905) expresses a longing for a mystic union with God. *New Poems* (1907, 1908) contains works that try to express the essence, or "idea," of an object or experience. Rilke's novel *The Notebooks of Malte Laurids Brigge* (1910) is a highly innovative "modernist" work in style and structure. It portrays the loneliness and confusion of a young poet searching for identity in turbulent Paris. The *Duino Elegies* (1923) and *Sonnets to Orpheus* (1923) are poems that praise human existence.

Rilke was born in Prague. He spent much of his life wandering through Europe.

Rimbaud, Arthur (1854-1891), was a French poet. He wrote his major poems during five turbulent years between the ages of 15 and 20. The poem that first won him recognition was "Le Bateau ivre" ("The Drunken Boat," 1871). Looking at a toy boat in a park pool, Rimbaud makes it sail in his imagination through luminous oceans and dazzling landscapes.

Rimbaud's major collection of free verse and prose poems is *Les Illuminations.* It was published in 1886, long after the poet had abandoned literature to become a trader in Ethiopia. The work shows what the world might have looked like after the Flood to a person not bound by preconceived habits and impressions. *Une Saison en enfer* (*A Season in Hell,* 1873), is an autobiographical account of the most tormented moment in

Rimbaud's young life, when he lost faith in reality and madness hovered over him. Rimbaud managed to free himself of this torment, just as he freed himself of the emotional entanglement with poet Paul Verlaine, which had caused the anguish. Rimbaud and Verlaine were close friends and travelled together in 1873 and 1874.

In a famous letter, Rimbaud stated his poetic principle: that the only real subject of poetry was the exploration of self through "a systematic derangement of all the senses"; the poet must search for a more dynamic use of language: "the alchemy of the word." Rimbaud was born in Charleville.

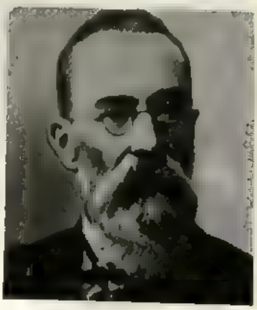
See also **Verlaine, Paul; French literature** (Symbolism).

Rimsky-Korsakov, Nikolai (1844-1908), was a celebrated Russian composer and teacher. He is especially known for his imaginative and colourful orchestral compositions. These compositions include *Spanish Capriccio* (1887), *Scheherazade* (1888), and the *Russian Easter Overture* (1888). Russian folk songs can be heard in Rimsky-Korsakov's music, as can choral music and bell ringing of the Russian Orthodox Church.

In spite of his orchestral successes, Rimsky-Korsakov's main emphasis was on opera. He based many of his 15 operas on Russian history and folklore. Only two of them, however, have gained success outside Russia. They are *Sadko* (1898) and *The Golden Cockerel* (1909). But still popular today in Russia are *The Snow Maiden* (completed in 1881, revised about 1895), *The Tsar's Bride* (1899), and *The Tale of Tsar Saltan* (1900). His masterpiece, *The Legend of the Invisible City of Kitezh and the Maiden Fevroniia* (1907), is virtually unknown in the West. Two of his best-known pieces come from his operas—"Song of India" from *Sadko* and "The Flight of the Bumblebee" from *Tsar Saltan*.

Rimsky-Korsakov was born in Tikhvin, near Novgorod. In 1861, he met the composer Mily Balakirev and joined a group of his students who later became known as The Five. Balakirev encouraged them to draw upon their Russian heritage in their music.

In 1871, Rimsky-Korsakov joined the faculty of the St. Petersburg Conservatory. Realizing he knew almost no music theory, he began to teach himself counterpoint, harmony, and musical form. As a musical theorist and teacher, he had a decisive influence on the course of Russian music in the early 1900's. Several of his students became important composers, including Sergei Prokofiev and Igor Stravinsky. His book *Principles of Orchestration* (published in 1913, after his death) has become a standard work. He also wrote an autobiography, translated into English as *My Musical Life*.



Nikolai Rimsky-Korsakov

Rimsky-Korsakov edited and revised compositions that his friends Alexander Borodin and Modest Mussorgsky had left unfinished at their deaths. Today, his version of Mussorgsky's opera *Boris Godunov* is usually performed. Borodin's opera *Prince Igor* is usually performed in the version completed by Rimsky-Korsakov and Russian composer Alexander Glazunov.

Rimu is the name of several species of tall New Zealand trees. One species is also known as *red pine*. Its timber, beautifully marked and much prized, is used in house building. Rimus may be planted to control soil erosion. They are majestic, tall trees with pale-green drooping branches and fine leaves pressed close along the stem. Like all pines, they have inconspicuous flowers that are either male or female. The flowers are borne on the ends of the branches, the males in catkins, the females in small cones. Each tree bears only male or female flowers.

Scientific classification. The rimu belongs to the family Podocarpaceae, genus *Dacrydium*. The red pine is *D. cupressinum*.

See also **Tree** (Familiar broadleaf and needleleaf trees [picture]).

Rinderpest, also called *cattle plague*, is a highly contagious, acute disease of cattle and other members of the ox family. Symptoms include sudden loss of milk production in cows, fever, and prostration. The cause is a virus. The death rate is as high as 98 per cent.

The disease hindered the development of Western civilization for many hundreds of years. It swept over Europe from the East with every war. The last European outbreak occurred in Belgium following World War I (1914-1918). The disease nowadays is chiefly confined to Oriental countries.

Ring is a circular band made of metal or other material worn as jewellery. Some rings are decorated with gems or engraving. Rings are commonly worn on the fingers, but they may also be worn on the ears, nose, or toes.

Rings have traditionally been a symbol of authority. For example, each new pope receives a special ring engraved with a picture of Saint Peter in a fishing boat. After the pope dies, the ring is destroyed and a new one is made for the next pope.

A ring is often used to symbolize an engagement or marriage. Engagement and wedding rings were first worn by the ancient Romans. Early wedding rings were made of iron. The custom of decorating engagement and wedding rings with gems began about 1200. During the 1600's, many people exchanged *posey rings* as a sign of love or friendship. This ring was a simple band engraved with a short love poem.

Rings may indicate membership or rank in an organization. Another popular type of ring has a gem that is associated with the month of a person's birth (see **Birthstone**).

In the past, people used *signets*, which were small seals attached to rings, to authenticate official documents. Rings were once used to indicate social status. In ancient Egypt, the wealthy wore heavy gold and silver rings. The poorer Egyptians wore rings made from bronze, glass, and glazed pottery.

See also **Jewellery**.

Ring, Christy (1921-1979), was one of Ireland's greatest hurlers. He began playing for Cork in intercounty hurling matches in 1937. He joined Glen Rovers in 1940 and won his last cap for County Cork in 1963. Ring won eight All-Ireland Senior Hurling Medals, the last of them in 1954. Ring was born at Cloyne, County Cork.

Ring of the Nibelung, The. See **Opera** (*Ring of the Nibelung, The*).

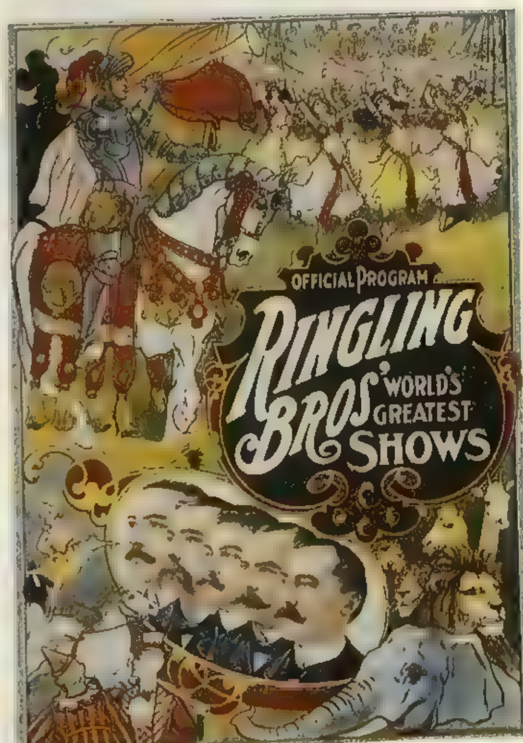
Ringette is a team sport for girls and young women that is similar to ice hockey. The game was invented in Ontario, Canada, in 1963. It is now played in the northern United States and in several European countries as well as in Canada.

As in ice hockey, ringette teams have six players, all of whom wear ice skates. The game is played on a rink divided into three sections by blue lines. The object of the game is to score goals by shooting a hollow rubber ring into a net guarded by a goaltender. The ring has an outer diameter of 16.5 centimetres, an inner diameter of 11.5 centimetres, and a thickness of 2.7 centimetres. Players use a straight stick that resembles a bladeless ice hockey stick to shoot and pass the ring. Most sticks are made of wood, but aluminium and plastic sticks are also used.

Ringette is a team sport for girls and women that is similar to ice hockey. Players skate on an ice-covered rink, and use a straight stick to pass and shoot a hollow rubber ring.

In ringette, the players must wear knee and elbow pads and helmets with face masks. Players commonly wear a track suit as a uniform, sometimes combined with an ice hockey sweater.

A ringette team consists of a goaltender, a centre, two forwards, and two defensive players. The centre is the only player who can skate anywhere on the ice. Forwards may not skate closer to the net their team is defending than the blue line nearest the net. Defensive players may not come closer to the net their opponents are defending than the blue line nearest the net. Centres play with white sticks, forwards with blue sticks, and defensive players with red sticks. Ringette games consist of two 15-minute halves. Violations are similar to those of ice hockey. However, unlike ice hockey, ringette prohibits body contact and requires passing over each blue line.



The five Ringling brothers built up the world's largest, most famous, and most spectacular circus in the early 1900's.

Ringling brothers were five brothers who founded the most famous circus in American entertainment history. The brothers were Albert (1852-1916), Otto (1858-1911), Alfred (1861-1919), Charles (1864-1926), and John (1866-1936). Their dedication and organizational skills helped build a small group of performers into one of the greatest circuses in the world.

The Ringlings were the sons of a harness maker from

Germany. Albert was born in Chicago, Otto in Baraboo, Wisconsin, and Alfred, Charles, and John in McGregor, Iowa. In 1884, the brothers started a travelling circus. At the time, there were a number of circuses touring the United States, including the huge Barnum show that travelled on 60 railway carriages. The Ringlings had little money for equipment or performers, so they did most of the work themselves. They held their first performance on May 19, 1884, in Baraboo. The brothers and 17 other employees sewed and pitched the tent, sold tickets, played in the band, and performed the acts.

Two other brothers, Henry and August, joined the Ringling circus later in the 1880's. Each of the seven brothers was responsible for one aspect of the circus management. The brothers invested almost all the profits back into the circus, which grew rapidly. At first, they took their show from town to town in wagons pulled by horses. By 1890, the circus travelled by railway. The Ringlings soon became strong competitors of the Barnum & Bailey circus, the largest circus of the time. In 1907, the Ringlings purchased the Barnum & Bailey circus, but the two shows toured separately until 1919. That year, they merged to form the Ringling Brothers and Barnum & Bailey Circus. The Ringling family sold the circus in 1967, but the new owners kept the name.

See also **Barnum, P. T.; Circus.**

Ringtail is a slender, quick-moving member of the raccoon family. Ringtails have grey-brown bodies that measure from 30 to 40 centimetres long. The fluffy tail is 35 to 45 centimetres long and is ringed with black and white stripes. The ringtail has a sharp nose and large ears and eyes.

North American ringtails live in deserts and forests from Oregon to southern Mexico and east into Colorado and Texas. These animals build nests in caves, hollow trees and logs, and cracks among rocks. They make their nests of bark, grass, leaves, or moss. The Central American ringtail, or cacomistle, a slightly larger species, lives in the forests of southern Mexico and Central America.

In May or June, most female ringtails have two to four babies. The young can hunt for themselves by September. Ringtails live for up to 10 years. These animals sleep during the day and hunt at night. They eat mostly rodents. They also feed on birds, insects, and other small animals, as well as fruit.

Some ringtails live near mountain cabins because of the mice they can catch there. They can be tamed and make good pets and *mousers* (mouse catchers).

Scientific classification. Ringtails are members of the raccoon family, Procyonidae. They make up the genus *Bassariscus*. The North American ringtail is *B. astutus*. The cacomistle is *B. sumichrasti*.

See also **Animal** (picture: Animals of the deserts).

Ringworm is a general name for several kinds of skin diseases that are caused by tiny plants, or fungi. Itching may or may not be a symptom. Common ringworm of the skin is often seen on children. It begins as a small red area the size of a split pea. This grows larger, and sometimes reaches the size of a large coin. The inside of the area clears, and the eruption appears as a red, scaly ring. There may be one or several patches. This form of ringworm occurs on the non-hairy parts of the body. It is infectious, but it can usually be easily cured if treated with antifungal ointment prescribed by a doctor. The spots of this type of ringworm may disappear without treatment after a few weeks, or they may persist for months. Body ringworm may attack people of any age. Flat yellowish or brownish patches may appear on the patient's neck, back, chest, or abdomen.

Ringworm of the hands and feet is common. The commonest type, affecting the skin between the toes, is commonly called *athlete's foot.* It may not cause discomfort, but is sometimes followed by the *vesicular* form, which causes eruptions of blisters on the hands and feet.

There may also be ringworm of the hairy parts of the body. Children are especially susceptible to ringworm of the scalp, which they sometimes contract from other children or from dogs and cats. Epidemics of ringworm of the scalp may occur in schools. If ringworm appears in a family, each affected person should use only his or her own comb and other personal items. The disease is highly infectious.

See also **Athlete's foot; Itch.**

Rio de Janeiro, Brazil (pop. 5,093,232; met. area pop. 9,018,637), is the second largest city of South America. Only São Paulo, the industrial centre of Brazil, has more people. Rio de Janeiro, often called simply *Rio,* ranks as an important centre of finance, trade, and transportation. The city also has one of the chief seaports of South America. Rio is the capital of the state of Rio de Janeiro in southeastern Brazil (see **Brazil** [political map]).

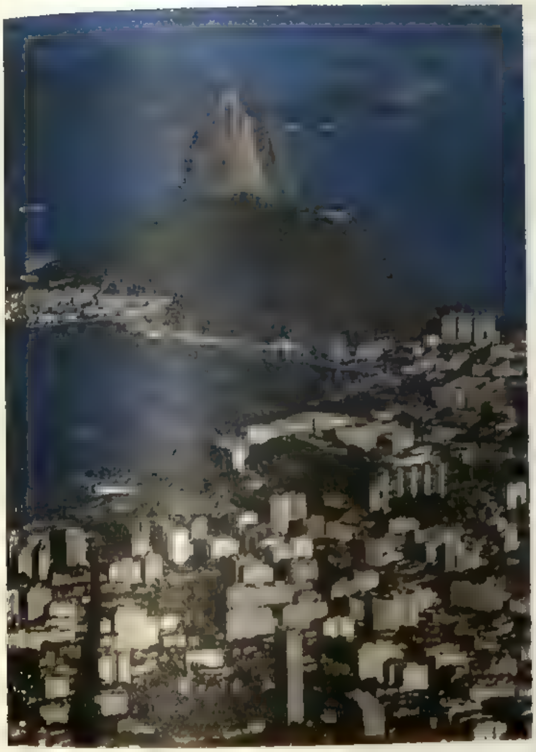
The exciting scenery of Rio de Janeiro makes the city one of the most beautiful in the world. Rio lies between forested mountains and the sparkling blue waters of the Atlantic Ocean and Guanabara Bay. Gleaming white beaches and graceful palm trees rim the shore. Sugar Loaf Mountain rises 404 metres from a peninsula in the bay.

Rio de Janeiro is a crowded city. But in spite of the crowded conditions, many of the city's people consider Rio the best place to live in Brazil. They especially enjoy Rio's sunny beaches, lively nightclubs, and colourful festivals.

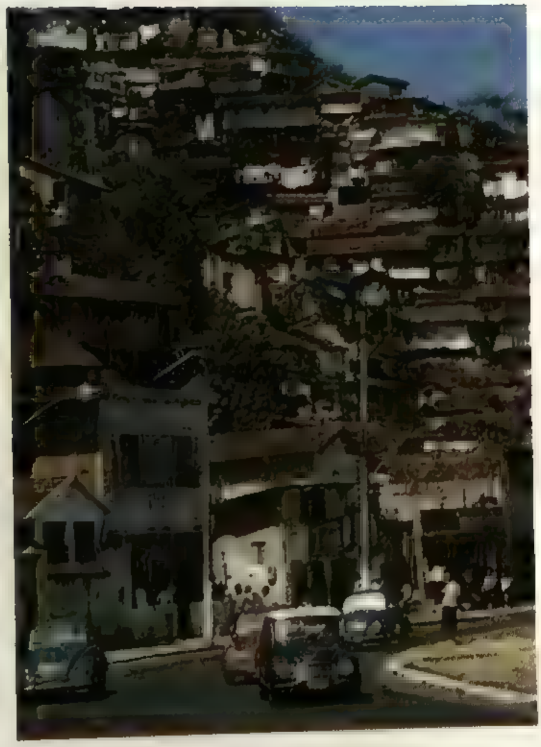
Rio was founded in 1565, when Portuguese soldiers built a fort and village near what is now Guanabara Bay. The Portuguese settled there in order to control the harbour. They named their village after the bay, which at that time was called Rio de Janeiro (River of January). Historians believe that Gonçalo Coelho, a Portuguese explorer, named the bay after the month in 1503 when he arrived there. Coelho thought the bay was the outlet of a great river.

The city covers about 1,171 square kilometres. The ocean shore forms Rio's southern boundary, and Guanabara Bay borders the city on the east. Mountains rise to the north and west, and the city itself includes many steep hills. A huge statue called *Christ the Redeemer* overlooks the city from the top of Corcovado Mountain, the highest of these hills.

Rio has three main sections called the north, centre, and south zones. The large north zone lies north of a line of hills that rises parallel to the ocean shore. This section, which includes the shore of the bay, has many docks and factories and large residential areas. The Rio-Niterói Bridge, which stretches about 14 kilometres, connects the north zone of Rio with Niterói, a city east of



Rio de Janeiro lies on Guanabara Bay, on the Atlantic Ocean. Sugar Loaf Mountain, a landmark of Rio, rises above the bay.



Small wooden homes crowd the hillsides of Rio de Janeiro. They provide housing for thousands of low-income families.

the bay. The water in parts of Guanabara Bay is polluted by sewage.

The small centre zone, which includes the main business district, lies at the entrance of the bay. In central Rio, large modern office buildings stand near pastel churches built during the 1700's. Traffic often crowds such broad boulevards as President Vargas and Rio Branco avenues. Other city streets are so narrow that only pedestrians may use them. Most of Rio's chief libraries, museums, and theatres are in the central zone. The main post office is in a palace that was once the home of Brazil's Portuguese rulers.

The long, narrow south zone occupies the land between the coastal hills and the ocean. This area includes a lovely lake, Rodrigo de Freitas Lagoon. Hundreds of tall blocks of flats overlook the many beaches of the area. Copacabana Beach is famous for its elegant hotels and patterned pavements made of coloured stone.

Slums called *favelas* form a sharp contrast to the luxury of Copacabana. Thousands of people live in shabby shacks on the steep hillsides and swampy shorelands.

Suburban communities lie in valleys near Rio. Many low-income workers live in these towns.

People of Rio have been called *Cariocas* since the city's early years. The Portuguese settlers may have taken this nickname from a South American Indian expression meaning *white man's house.* Today, Cariocas include people of American Indian, European, or African descent. Many have ancestors from two or three of these groups. Cariocas, like other Brazilians, speak Portuguese.

Most of the city's people belong to the Roman Catholic Church. But many of the Catholics also attend Pentecostal Protestant services, and others participate in *Macumba* religious ceremonies. Followers of Macumba pray to Christian saints, and they also worship the gods and goddesses of certain African religions. On New Year's Eve, hundreds of thousands of Cariocas crowd the beaches for candlelit Macumba ceremonies. These ceremonies honour the sea goddess Iemanjá.

Many Cariocas go to the beach to sunbathe, to swim, or to play volleyball. Crowds of as many as 200,000 fans cheer the soccer teams that play at Maracaña Stadium, one of the largest sports arenas in the world. In the evening, many people go to one of Rio's numerous nightclubs or chat with friends at a pavement cafe.

Rio has won fame for an annual festival called Carnival, which takes place just before Lent, the religious season that precedes Easter. Carnival features four days and nights of parades and dancing in the streets.

Education and cultural life. Rio's educational institutions, libraries, and museums make the city the leading cultural centre of Brazil. The Federal University of Rio de Janeiro ranks as the largest of the several institutions of higher learning. The city's libraries include the National Library, which has about 3 million books. Many visitors view the exhibits at such museums as the National Museum of Fine Arts, the Folklore Museum, and the Indian Museum. Concerts and plays are presented at the Municipal Theatre and other auditoriums.

Economy. Rio's banks and stock market make the city a centre of Brazilian finance. The city's factories produce

Rio de Janeiro *One of the most beautiful cities in the world.*

Brazil's second largest city (pop. 9,018,637), behind Sao Paulo.

Capital of state of Rio de Janeiro, in southeastern Brazil. Important centre of finance, trade, transportation. Major South American seaport.

Landscape makes Rio a tropical paradise: sparkling ocean waters, sandy beaches, forested mountains. Hot sunny climate and lively nightlife contribute to thriving tourist trade and carefree life style.

Copacabana Beach, *left,* is a world-famous resort area, known for its elegant hotels, lively nightlife, and great natural beauty. Visitors and *Cariocas* alike flock to Copacabana all year long. Cariocas are residents of Rio.

Christ the Redeemer statue, *below,* overlooks Rio from atop Corcovado Mountain. The statue can be seen from most places in the Rio area. A team of artisans headed by the French sculptor Paul Landowsky completed the statue in 1931. It is made of concrete and soapstone and stands about 30 metres tall. At night, floodlights shine on the statue.

1503
Portuguese explorers first arrived at Guanabara Bay.

1555
France established a settlement on the bay. The Portuguese founded Rio in 1565, and drove out the French by 1567.

1700's
Brazil's gold trade brought many settlers to Rio.

1763
Rio became capital of Brazil. Ruler of Portugal made Rio capital of Portuguese Empire in 1808.

1792
The revolutionary Tiradentes, Joaquim José da Silva Xavier (called "Tooth Puller"), was hanged in public after Portuguese uncovered his plot to win independence.

Portuguese buildings on Largo do Boticario, *left,* date back to the 1700's, when Portugal ruled Brazil. Many of Rio's colonial buildings have been replaced by modern structures.

The Gloria Church, *below,* or *Nossa Senhora da Gloria do Outeiro,* is a landmark of central Rio. It was built in the 1700's, in the Brazilian baroque style of architecture. The church overlooks Guanabara Bay.

The Botanical Garden, *above,* features thousands of different kinds of plants. Towering palm trees line the walkways of the gardens. The aroma of flowers sweetens the air, and huge water lilies float in scenic ponds. A botanical museum in the grounds houses part of an original palm planted when the gardens opened in 1808.

Cultural centre of Brazil: fine museums, libraries, educational institutions, plays and concerts.

Shops scattered throughout central Rio and beach areas feature country's native crafts, including tapestries, batik, wood carvings, masks.

Internationally famous Carnival festival takes place annually just before Christian season of Lent. Festival includes four days and nights of colourful parades, elaborate costumes, dancing in streets.

A Striking House, *below,* with its many turrets and balconies, is one example of the wide variety of architectural styles found in Rio.

1822
Brazil became independent nation with Rio as capital.

Mid-1800's
Steamship lines linked Rio with Europe and North America; trade expanded.

Late 1800's
Santa Teresa neighbourhood was established as Rio's finest residential area.

Early 1900's
Millions moved to Rio from rural Brazil. Housing shortages resulted.

1912
A cable car line carried its first passengers up Sugarloaf Mountain.

1975
Rio ceased to be the city-state of Guanabara when Guanabara was combined with the neighbouring state of Rio de Janeiro.

about 10 per cent of the nation's industrial output. Products of Rio include, in order of value, processed foods, chemicals, drugs, and metals. The city also has large shipyards.

Rio is a major transportation centre. Roads and railways link the city with other large Brazilian cities. Rio has two major airports and is one of Brazil's chief seaports. A ferry connects Rio with Paquetá Island in Guanabara Bay. An underground system and many buses provide local transportation.

History. Tupi Indians lived near what is now Guanabara Bay when Portuguese explorers first arrived there in 1503. Portugal had claimed the Brazil region as a colony in 1494. France established a settlement on the bay in 1555. Ten years later, Portuguese soldiers led by Captain Estácio de Sá founded Rio de Janeiro. They drove out the French in 1567.

Portuguese prospectors found gold in southern Brazil during the 1690's, and ships began to carry the precious metal from Rio to Portugal. The gold trade attracted many settlers to Rio during the 1700's, and the city became the capital of Brazil in 1763.

The ruler of Portugal, Prince John (later King John VI), came to Rio in 1808 to escape a French invasion of Lisbon, the Portuguese capital. He made Rio the capital of the Portuguese Empire. Thousands of other wealthy Portuguese also fled to Rio. They established medical and military schools and a large city library. Lisbon again became the capital of the empire in 1821, when John returned there. In 1822, Brazil became independent with Rio as its capital. Trade expanded after steamship lines linked Rio with Europe and North America in the mid-1800's. Rio had more than half a million people in 1890.

During the early 1900's, central Rio was modernized by many broad boulevards and new buildings. Millions of people moved to the city from rural Brazil during the early and mid-1900's. Thousands of blocks of flats were erected to provide housing for the growing population. But many of the newcomers could not afford to rent flats and had to live in shacks in the favelas. During the 1960's and 1970's, the federal government built a number of housing projects in Rio for low-income residents.

Brasília replaced Rio as the national capital in 1960, and the federal government moved there during the 1960's and 1970's. Many Cariocas who worked for the government did not go to Brasília, and so they lost their jobs. During the 1970's, the state government granted financial aid to manufacturers in an effort to attract new industrial employers to Rio de Janeiro.

In 1975, Rio annexed some of its suburbs and outlying areas. As a result, the city's area increased from 155 square kilometres to 1,171 square kilometres. The population increased by about 20 per cent.

For the weather in Rio de Janeiro, see **Brazil** (Land and climate). See also **Brazil** (pictures).

Río de la Plata is an estuary, or funnel-shaped bay, formed by the Paraná and the Uruguay rivers on the southeastern coast of South America. The bay extends northwestward from the Atlantic Ocean for about 270 kilometres. A great volume of water flows into the bay from the Paraná and Uruguay rivers, and there is a powerful current. Many dangerous shallows make sailing risky all along the river's course. The natural harbour of Montevideo, in Uruguay, lies near the mouth of the bay, which is 225 kilometres wide. On the Argentine side of the bay, at Buenos Aires and La Plata, huge docks have been built and deep channels have been dredged.

In 1516, Juan Díaz de Solís became the first white person to enter the bay. It was named Río de la Plata (Silver River) by Sebastian Cabot, the Italian navigator. Cabot probably chose the name because of the silver ornaments the Indian residents there wore at the time.

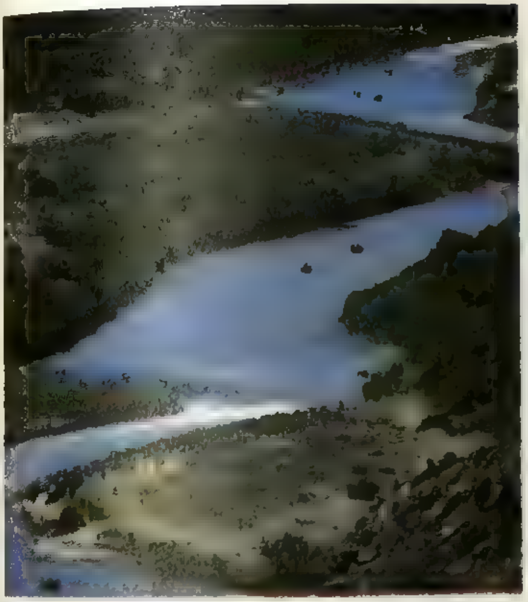
See also **Argentina** (terrain map).

Rio Grande, one of the longest rivers in North America, flows for 3,034 kilometres through the Southwestern United States. It forms the international boundary between the United States and Mexico for about 1,996 kilometres, or almost two-thirds of the common border. Early Spanish explorers gave the river its name. *Rio Grande* means *large river*. Mexicans call the river *Río Bravo* (*bold river*) or *Río Bravo del Norte* (*bold river of the north*).

Upper course. The Rio Grande rises on the Continental Divide in the southern Rocky Mountains in southwestern Colorado. It flows southeast through the San Luis Valley Reclamation Project. At Alamosa, the river turns south. It crosses into New Mexico, and flows from north to south through the centre of the state. In northern New Mexico, the Rio Grande, fed by mountain streams, passes through a series of basins separated by narrow valleys.

The Rio Grande's valley widens above Albuquerque, and the river flows out upon a dry plateau. Here Elephant Butte Dam impounds the river for about 65 kilometres. Farther downstream is the Caballo Reservoir. Both these reservoirs store water for the Rio Grande Reclamation Project at Las Cruces. The American Dam controls the waters of the Rio Grande north of El Paso at the Texas, New Mexico, and Mexico borders.

Rio Grande



The Rio Grande forms most of the United States border with Mexico. It flows from Colorado, U.S.A., to the Gulf of Mexico.

Middle course. From El Paso to the Gulf of Mexico, the Rio Grande forms the international boundary. The river flows southeast from El Paso to Presidio, where it turns north to pass around the mountainous Big Bend country. It then flows east until the Pecos River joins it. The Rio Grande turns southeast for the rest of its course. Amistad Dam spans the river about 20 kilometres northwest of Del Rio, Texas. The dam forms Amistad Reservoir, which extends upstream 138 kilometres. During its middle course, the Rio Grande flows through very dry country. The river may be dry in late summer, because of little rainfall and the amount of water used for irrigation. Railways cross the border at El Paso and Presidio.

Lower course. The Rio Grande widens between Eagle Pass and Laredo, both important railway crossings. About 80 kilometres below Laredo, the Salado River, a major tributary from Mexico, joins the Rio Grande. Falcon Dam, about 32 kilometres below the mouth of the Salado River, forms Falcon Reservoir, which extends upstream more than 55 kilometres. El Azúcar Reservoir lies across the Rio Grande at Camargo in Mexico. Farther downstream, at Mission, is Mission Reservoir. These reservoirs hold back floodwaters for the lower valley's irrigation projects. Between Rio Grande City and Brownsville, farmers grow citrus fruit, vegetables, and cotton in the irrigated valley.

In 1936, a 27-kilometre canal was built from Brownsville to Laguna Madre, which leads to the Gulf of Mexico. Most of the river is too shallow for boats.

Rio Madeira. See Madeira River.

Río Muni. See Equatorial Guinea.

Rio Tinto Zinc (RTZ Corporation plc) is one of the United Kingdom's largest companies. The company originally was based on the mining and processing of metals, and developed efficient, low-cost methods of extraction. Gradually, the company extended its operations into metal fabrication, engineering, construction materials, chemicals, and the supply of raw materials for energy production. The company's name came from its Rio Tinto mine in Spain.

Riot is a noisy, violent outbreak of disorder by a group of people. Rioters often harm other people and damage property. Rioting or urging people to riot is a crime in most countries. However, the precise legal definition of a riot differs from place to place. In many countries, riot is defined as a disturbance of the peace by three or more people prepared to use violence to enforce a common purpose. In other countries the offence is known as riotous or unlawful assembly.

Rioting cannot always be easily distinguished from vandalism, disorderly conduct, or other similar offences. But most riots involve hundreds or thousands of people, and follow an aggravation of already severe economic, social, or political grievances. A riot may break out spontaneously, or it may be carefully planned through conspiracy. Few riots—unlike revolts or rebellions—are aimed at overthrowing a government or removing specific leaders. However, a riot may set forces in motion that bring about such a result.

A riot may break out during a demonstration. In a demonstration, many people gather merely to protest publicly against some policy of the government, an industry, a university, or some other institution. But when passions run high, the massing together of thousands of people and the efforts of police to keep order can lead to violence. The constitution in many countries guarantees everyone the rights to assemble in peace, to petition the government with grievances, and to *dissent* (disagree) as an individual or in a group (see **Freedom of speech**). But when dissent changes into disruption of order and is accompanied by violence that injures others or causes physical damage, it is a riot.

Causes of riots

The specific issues that trigger riots vary. However, the underlying causes of many riots are similar. Many riots occur because some groups of people believe they do not have an equal chance for economic, political, or social advancement. Members of most minority groups live in this situation (see **Minority group**). Large numbers of people in such groups may feel they are mistreated by individuals or by government agencies or other organizations that strongly influence their lives. They may become depressed because they feel they cannot help make major decisions that affect themselves and their community. People who believe their grievances are being ignored often become defiant, and their feelings can erupt.

Members of a majority group may also become rioters if they fear a minority. They may attack members of the minority to keep them in an inferior social or economic position.

Many social scientists classify riots into two groups: (1) *instrumental riots* and (2) *expressive riots.*

Instrumental riots occur when groups resort to violence because of discontent over specific issues. Throughout history, most riots have been of this type. The violence results from attempts to change certain policies or to improve certain conditions. Most labour riots, especially those in the past, fall into this category. During the 1800's and early 1900's, for example, trade

During a riot in London's Trafalgar Square, riot police carrying truncheons try to disperse the crowds.

unionists in many countries fought vigorously to improve working conditions in mines, on railways, and in factories. Union disputes with management often resulted in violence. Discontent with employers arose again in the late 1900's in the United Kingdom. Redundancies in such industries as printing and mining led to large scale confrontations with police and rioting.

Other instrumental riots include prison, election, anti-war, and student riots. Election riots took place in South Africa in 1989. Only the white minority had the right to vote because of the government's policy of apartheid (see **Apartheid**). Election riots also took place in Panama in 1989 because voters did not believe that the administration would count their votes fairly or abide by the result.

Instrumental riots often indicate that the organizations being attacked have not listened effectively to or acted upon grievances previously voiced through orderly channels. But most people condemn the use of violence to achieve even the most desirable goals when peaceful means of change are available.

Expressive riots occur when many people in a minority group use violence to express dissatisfaction with their living conditions. Studies of urban riots from the 1960's onward show that members of minority ethnic groups in the riot areas had many grievances, including few job opportunities, bad housing, and inferior schools. People also complained of the use of what they felt was excessive force by the police. Several of the riots were triggered by arrests or other routine police actions that people of the minority groups considered to be police provocation or brutality. These police actions brought large, angry crowds onto the streets in protest. The small number of police at the scene could not control them.

The resulting riots become chiefly symbolic gestures of widespread discontent. For some rioters, however, they become opportunities to loot stores for personal gain. For others, the riots are little more than destructive play. In trying to restrain the rioters and promote a return to order, the police sometimes use more force than many people think necessary. Such action then causes many rioters to become even more violent.

Riot police

In some countries, such as France, there are specially trained police divisions to deal with riots. In others, ordinary police officers are trained to use special riot equipment when necessary. The officers may wear helmets and carry shields to protect themselves against stones and other missiles. They may also be armed with truncheons for defence. In some countries police use tear gas or water cannon to disperse rioters. Rubber bullets or even live ammunition may be fired (see **Ammunition** [Riot control ammunition]). Some forces use police mounted on horses for riot control. They help break up crowds and keep people moving.

History. Riots have occurred throughout the world since the beginning of history. In most societies, at one time or another, the poor have rioted to press their demands for food. In ancient civilizations, food riots were recorded in Egypt, Greece, and Rome. But poverty and need were not the only reasons for people to riot. In ancient Greece, the citizens rioted against the *tyrants* (the leaders who ruled them) and demanded a new form of government.

In the late Middle Ages, in Europe, peasants rioted against their feudal lords to try to win their freedom. Hunger, poverty, and disease had made them desperate. In England, the peasants found a leader in Wat Tyler (see **Wat Tyler's Rebellion**).

In the early 1800's, workers rioted against low wages and terrible working conditions during the Industrial Revolution. The introduction of new machines had caused unemployment and hardship. One group of rioters in England, called Luddites, attacked factories and broke machines (see **Luddites**). Agricultural workers also attacked the machinery that was creating unemployment on the land. Machine breakers were arrested and many were transported as convicts to Australia (see **Convicts in Australia**).

Demands for political reform in the United Kingdom

Major riots of the 1900's

1919	U.S.A.: efforts to unionize the steel industry led to riots at plants in Indiana, Ohio, and Pennsylvania.
1938	Germany: on the night of Nov. 9, Nazis organized a riot to attack Jews and Jewish businesses. It became known as *Kristallnacht* (Crystal Night). In English, it is called the Night of Broken Glass.
1946	India: Hindu/Muslim unrest before the partition of India into the separate countries of India and Pakistan.
1953	East Germany: harsh living conditions led to anti-Communist riots in East Berlin. Rioting spread to other parts of the country but was put down by military intervention from the Soviet Union.
1960	South Africa: unrest followed when police opened fire on antiapartheid protesters at Sharpeville, in the southern Transvaal, killing 69 people.
1965	U.S.A.: discontent in the black community led to violence and rioting in Watts, Los Angeles.
1968	France: student demonstrations against President de Gaulle caused clashes with police. Violence spread throughout France.
1968	U.S.A.: clashes between police and demonstrators against the Vietnam War (1957-1975) took place in Chicago during the Democratic National Convention.
1969	Northern Ireland: Catholic/Protestant demonstrations in Londonderry led to the beginning of a strong military presence in the country.
1971	U.S.A.: a prison riot at the state prison in Attica, New York, resulted in the deaths of 11 guards and 32 prisoners.
1980	Korea: civilians rioted against military presence after the declaration of *martial law* (rule enforced by the army). Hundreds of demonstrators were killed.
1980/81	England: discontent at rising unemployment led to riots in Bristol, Brixton, and Toxteth.
1984	India: Hindu/Sikh rioting followed when Prime Minister Indira Gandhi was assassinated by two of her Sikh bodyguards.
1987	Israel: Arabs in the Gaza Strip and West Bank began violent protests, known as *intifada* (uprising) in which both Arabs and Israelis were killed.
1987/88	Burma: antigovernment riots followed a poor rice harvest. As a result of the rioting the government declared martial law.
1989	China: students demonstrated in Tiananmen Square, Beijing, for greater democracy. As a result the army attacked the square, killing hundreds of students.
1992	U.S.A.: riots erupted after an all-white jury decided not to convict 4 white police officers in Los Angeles of assault on a black motorist. The riots resulted in 51 deaths.
1992/93	India: Hindu/Muslim rioting followed the Hindu destruction of a mosque in Ayodhya in northern India. More than 1,000 people were killed.
1993	South Africa: rioting followed the murder of Chris Hani, leader of the Communist Party.

during the 1800's also led to rioting, and to severe reactions from the government of the time. In 1830 and 1848, riots led to revolutions in Belgium, France, Germany, and the Austrian Empire.

In the 1900's, dissatisfaction with the continuation of colonial government caused many riots around the world. Distrust between religious groups, or groups from different ethnic backgrounds, also resulted in rioting. Social injustice, unemployment, and demands for greater democracy have all been the cause of major riots.

Riot police wear helmets and carry plastic shields. Their van has a grille to protect the windscreen from missiles.

Related articles in *World Book* include:

Chartism	Peterloo
Gordon Riots	Rebecca riots
July Revolution	Revolution
Peasant's War	Revolution of 1848

Rip Van Winkle is one of the most popular characters in American literature. Washington Irving wrote the famous short story "Rip Van Winkle" about a cheerful ne'er-do-well who falls asleep for 20 years. The tale first appeared in Irving's collection *The Sketch Book of Geoffrey Crayon, Gent.* (1819-1820).

The story takes place in the Catskill Mountains of New York during colonial times. Rip, an unsuccessful farmer, goes hunting one day to escape his wife's continual nagging. In the woods, he helps a stout little man in old-fashioned clothing carry a keg of liquor up a mountain. Near the top, they come upon a group of men dressed like Rip's companion. Rip drinks from their keg and falls asleep.

After awakening, Rip returns to his village and learns that 20 years have passed since he fell asleep on the mountain. During that time, his wife has died, his children have grown up, and the colonists have won the American Revolution. At first, everyone laughs at Rip's story. But the oldest villager confirms it by revealing that the men Rip met on the mountain were the ghosts of the English explorer Henry Hudson and his crew. Rip then becomes famous for his adventures.

Irving based his story on the German legend "Peter Klaus." However, his descriptions of local scenes and customs in "Rip Van Winkle" gives the story its own distinct charm.

See also **Irving, Washington.**

Riparian rights are the legal rights of a landowner whose property borders or forms the bed of a stream or river. Each country has its own rules relating to riparian rights. Generally, each riparian owner has a right to the flow of water in the stream, and to use it reasonably. The owner's permission is required for any increase or decrease in the flow, any move to change the flow's direction, or any action that would make the water dirty. The

owner may own the land extending to the centre of the bed of a stream, or only to the usual high-water mark along a navigable stream.

Where water is scarce, riparian rights are either limited or do not exist. In some places, reasonable use of water by riparian owners has been replaced by the right of *prior appropriation.* This right gives legal use of the water to the person who takes it first. Other persons may use any remaining water. The term *riparian* comes from the Latin word *ripa,* which means *riverbank.*

Ripley, Robert LeRoy (1893-1949), was an American cartoonist who became internationally famous for his cartoon panel "Believe It or Not." The panel describes oddities and strange facts and occurrences from around the world. At its peak of popularity, the daily newspaper readership of "Believe It or Not" was estimated at 80 million. The feature also provided material for lectures and personal appearances by Ripley, and for radio and television shows, books, films, and museums.

Ripley was born in Santa Rosa, California, U.S.A. He was born LeRoy Ripley, and he later added "Robert" to his name. He began his career as a sports cartoonist for the *Bulletin* and the *Chronicle* in San Francisco and the *Globe* in New York City. The first "Believe It or Not" panel appeared in the *Globe* on Dec. 19, 1918.

Rippon, Geoffrey (1924-), a British Conservative politician, was chancellor of the Duchy of Lancaster from 1970 to 1972. In this post, he negotiated Great Britain's entry into the European Common Market, which took place on Jan. 1, 1973. From 1972 to 1974, Rippon was secretary of state for the environment. Aubrey Geoffrey Frederick Rippon was educated at Oxford University. He was a member of Parliament from 1955 to 1987, and held ministerial posts from 1961 to 1964 and from 1970 to 1974.

Risdon is a cove on the eastern shore of the Derwent River in Tasmania. It was named by Captain John Hayes in 1794. In September 1803, Risdon Cove was settled by Lieutenant John Bowen with 49 people, 24 of whom were convicts. Later it was the scene of a clash between a large hunting party of Aborigines and soldiers. Several of the Aborigines were killed. When Lieutenant Colonel David Collins settled at Sullivan's Cove (the present-day site of Hobart) in 1804, he took over the Risdon settlement.

Rite of passage is a ceremony held by nearly all societies to observe a person's entry into a new stage of life. Rites of passage note such occasions as birth, graduation, or marriage. Christian *confirmation* and Jewish *bat mitzvah* and *bar mitzvah* are rites that celebrate the reaching of spiritual adulthood.

Most rites help people understand and accept their new roles in society, and help others learn to treat them in new ways. Generally, the most complicated rites are those for a new role that demands a great change in behaviour.

Most rites of passage have three stages—*separation, transition,* and *incorporation.* First, a participant in a rite of passage is temporarily separated from the rest of society and the routine of his or her former role. During the transitional, or in-between, stage of a rite of passage, the participant learns the behaviour appropriate to the new position. After this the participant is formally incorporated, or admitted, into the new role.

People often pass through rites as a group. Members of a group give one another support. In some African societies, boys who will soon become adults are separated for days or months while they learn tribal legends and technical skills.

Participants in most rites of passage wear special costumes to emphasize their temporary separation from society and to symbolize the change they experience. Such costumes include wedding dresses and graduation gowns. In some African societies, members of groups in transition even share a secret language.

The term *rites of passage* was invented by anthropologist Arnold van Gennep of France to describe what he regarded as the common purposes of such ceremonies as baptisms, weddings, and funerals. Van Gennep described these similarities in his book *Les Rites de Passage* (1909).

Each rite discussed in this article has a separate article in *World Book.*

Rittenhouse, David (1732-1796), of Philadelphia, in the United States, was a leading astronomer, mathematician, and clockmaker. In 1769, he measured the earth's distance from the sun. Astronomers were able to use his measurements to determine the distance of other planets from the sun. Rittenhouse built a precise model of the solar system in 1770. In 1782, he built a pendulum that made clocks more accurate. He became the first director of the United States Mint in 1792. Rittenhouse was president of the American Philosophical Society from 1791 to 1796, and was elected to the British Royal Society in 1795. He was born in Germantown, Pennsylvania.

Ritty, James (1836-1918), an American restaurant owner, invented the cash register. While travelling to Europe in 1878, he saw a device for counting the revolutions of the ship's propellers. When he returned home, he devised a similar machine to record business transactions. In 1879, he and his brother John built and patented a gear-operated adding machine. Later they built a simpler paper-punch register. The Rittys sold the business in 1881. James Ritty was born in Dayton, Ohio.

Ritual. See **Religion** (Religious rituals).

River is a large body of water that flows over land in a long channel. Most rivers begin high in the mountains or hills. A river's *source* may be a melting snowfield or glacier, a spring, or an overflowing lake. As a river flows in its channel, it receives more water from streams and other rivers, and from rainfall. At the end of a river is its *mouth,* where the water empties into a larger river, a lake, or an ocean.

Rivers vary greatly in size. Some are so small that they dry up during hot, dry seasons. The longest river is the Nile River in Africa, which flows 6,671 kilometres. The next longest river, the Amazon River in South America, measures 6,437 kilometres. But it carries more water than any other river—more than the Nile, the Mississippi, and the Yangtze together. See **World** (graph: Longest river on each continent).

Rivers have been important to transportation and trade for many centuries. The river system of Europe is useful in trade to the present day. Explorers and pioneers in North and South America used rivers as their main travel route, and settlements were built along major rivers. The exploration of the interior of Africa

in the 1800's was also based to a large extent on tracing the courses of the continent's great rivers. Similarly, following the crossing of the Blue Mountains in 1813, the early explorers of eastern Australia also followed the courses of rivers. They wanted to discover whether the rivers of the Darling-Murray system linked up or whether they flowed into an inland sea.

Rivers are also valuable to agriculture because their valleys and plains provide especially fertile land for growing crops. Farmers in dry regions use river water to irrigate their land. They dig irrigation ditches to carry water from a river to the farmland.

Rivers also serve as an important energy source. The force of flowing water at waterfalls or other steep places along a river can be used to run machines and to generate electricity. Water wheels and water turbines change the force of the flowing water into energy. For many years, flour mills, machine shops, and textile mills were built near steep rivers and operated by water power. Today, *hydroelectric* (water turbine) plants produce about a quarter of the world's electric power. See **Water power.**

Heavy rainfall or the rapid melting of winter snow sometimes causes rivers to overflow. This flooding may wash away large amounts of fertile farm soil, destroy buildings, and injure or kill people and animals. See **Flood.**

The source of a river. A river's water comes from a combination of rainfall, lakes, springs, and melting ice and snow. The various streams that flow from the river's source are called the *headwaters.* A river has its highest elevation at its headwaters. At first, the headwaters flow in tiny, narrow channels called *rills.* These channels are filled only during rainstorms. As the rills travel downhill, they come together, forming wider, deeper channels called *brooks.* In turn, brooks combine to form *streams,* and streams join to form rivers. All of the brooks and streams that carry water to a river are called *tributaries.* A river and its tributaries form a *river system.* Some river systems have several small rivers that flow into one large one.

Rainfall provides most of the water for rivers. Some of the rain flows over the land into the waters of the river system. This rain will eventually reach the largest river in the system by way of the rills, brooks, streams, and smaller rivers. The rest of the rain soaks into the ground and accumulates as *ground water.* Some of this ground water seeps into the river system and keeps water flowing in most rivers even during dry periods. In hot, dry regions, however, there is not always enough overland flow or ground water to keep some rivers flowing all year round. These rivers dry up from time to time and are called *intermittent rivers.* For example, in the dry continent of Australia, many inland rivers are intermittent and some of them vanish into the sandy deserts and salt lakes in the heart of the continent. By contrast, Tasmania and New Zealand have heavy rainfall and their rivers are *perennial*—that is, they flow continuously. But the flow of all rivers varies with changes in weather and climate.

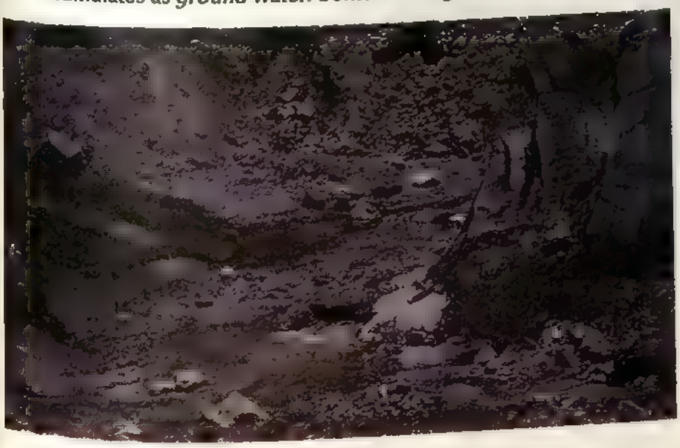
The waters of a river system make up the *drainage net* of that land area. The region drained by a river system is called the system's *drainage basin.* The Amazon River has a drainage basin of about 7,000,000 square kilometres. The catchment area of the Murray River in southeastern Australia covers nearly one-seventh of the area of Australia.

An imaginary line called a *watershed* or a *drainage divide* separates the drainage basins of major rivers. This line often follows the *crest* (top) of a high mountain range, such as the Rocky Mountains in North America which separates rivers that flow east to the Atlantic Ocean or west to the Pacific. The Great Dividing Range in Australia is another divide. See **Divide.**

The channel of a river consists of the land on either side of and beneath the flowing water. The bottom of the channel is called the *bed,* and the edges are the river's *banks.* The slope of the channel tends to be steep near the source of a river and almost flat near the mouth. As a result, the flow of water in most rivers is fastest in the upper course.

In many rivers, *waterfalls* and *rapids* exist in the upper course. Waterfalls occur where a river crosses a layer of strong, resistant rock. Softer rock downstream is *eroded* (worn away) by the flow of water, leaving a steep drop in the river's channel. As water passes over the edge of the harder layer, it falls down to the lower part of the channel. Rapids result from water tumbling over large boulders or rock ledges in the river channel. The current of fast-flowing rivers sometimes cuts a *canyon,* a deep channel with high walls worn into the river's bed.

The upper course of a river also may cut valleys through the land. As a river flows swiftly down a hill or a mountain, the force of the water erodes the land, creat-



The source of the Ganges River is in the melting ice of the Himalaya of northern India. It is a place of pilgrimage for many Hindus.

ing a steep, V-shaped valley that rises from the river's banks. Geographers often call the upper course of a river the youthful stage. They call the middle course the mature stage, and the lower course, when the muddy river flows slowly across the land, is called the old age stage.

In the mature stage, the river still flows vigorously, wearing away the land as it swings around bends. Its valley is broader than it was in the youthful stage.

In the old age stage, most rivers flow across relatively flat areas. These areas are called *flood plains*. They are covered by water when the river floods. Floods spread fertile mud and silt over the land. They may also create *natural levees*. These formations consist of *sediment* (earth and rock) that raise the river's banks. Marshy areas occupy the flood plains next to the natural levees.

Some rivers have flood plains hundreds of kilometres wide. Where broad flood plains exist, the river channel tends to curve from one side of the plain to the other. These snakelike bends are known as *meanders*. Meanders can form almost complete loops, with only a narrow neck of land separating the beginning and end of each loop. When the river floods, it often cuts across this neck. After the floodwaters go down, the river once again flows straight and the loop no longer carries river water. Instead, it fills with rain water or ground water and may remain for many years as a crescent-shaped lake, called an *oxbow lake*.

The mouth of a river. The flow of a river's water slows down dramatically at its mouth. This decrease in speed may cause the creation of a body of land called a *delta*, which builds up at the mouth and stretches out into the lake or ocean into which the river empties. Deltas form because a river carries the products of erosion and rock decay toward its mouth. This material is called the river's *load*. Most of the material is dissolved in the

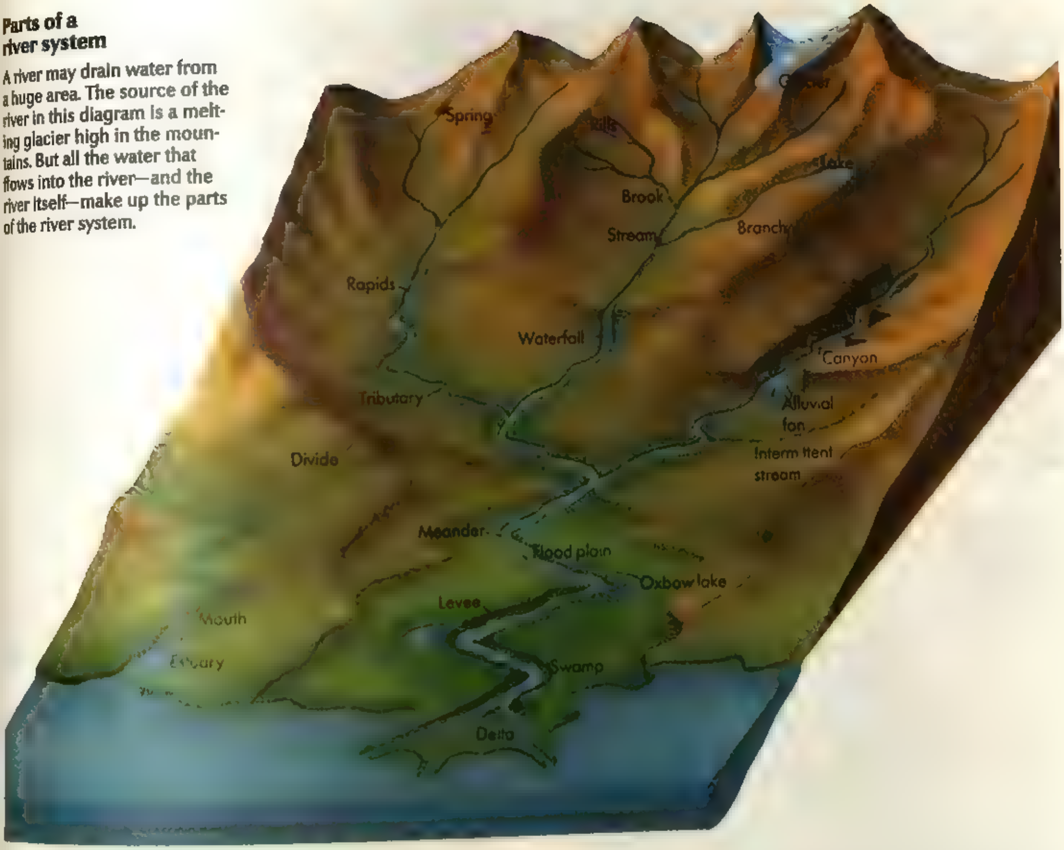
Famous rivers of the world

Name	Length* in kilometres	Location	Interesting facts
Amazon	6,437	South America	Carries more water than any other river; world's second longest river; only the Nile is longer.
Colorado	2,334	United States	River's current, combined with other agents of erosion, created the Grand Canyon.
Congo (Zaire)	4,667	Africa	Fifth longest river in the world and second in the amount of water carried.
Danube	2,860	Europe	Its beauty inspired Austrian composer Johann Strauss, Jr., to write the famous waltz "On the Beautiful Blue Danube."
Darling	2,739	Australia	Australia's longest river; it is a tributary of the Murray, but is mostly dry in winter.
Ganges	2,478	India-Bangladesh	Considered sacred by members of the Hindu faith.
Huang He	4,672	China	Name means *yellow river*; large amounts of yellow silt are deposited along its course.
Indus	2,897	Tibet-Pakistan	Source of one of the largest irrigation systems in the world.
Jordan	320	Israel-Jordan	River mentioned most often in the Bible.
Mackenzie	1,724	Canada	Canada's longest river.
Mekong	4,180	Asia	Largest river on the Indochinese Peninsula.
Mississippi	3,766	United States	Second longest river in the United States.
Missouri	4,090	United States	Longest river in the United States.
Murray	2,589	Australia	Australia's longest permanently flowing river
Niagara	55	United States-Canada	Famous for its spectacular Niagara Falls.
Niger	4,180	Africa	Its delta is the largest in Africa.
Nile	6,671	Northeast Africa	World's longest river.
Rhine	1,320	Europe	Most important inland waterway in Europe, a German symbol of national history and strength.
Rio Grande	3,034	United States-Mexico	Spanish name for *large river*; forms part of international boundary between United States and Mexico.
St. Lawrence	1,300	Canada-United States	Canada's second longest river; links the Great Lakes and the Atlantic Ocean.
Seine	764	France	Flows through the heart of Paris, where more than 30 bridges span it.
Shannon	370	Ireland	Longest river in Ireland.
Thames	346	United Kingdom	Longest and most important waterway entirely within England; flows through the centre of London.
Volga	3,531	Russia	Longest river in Europe.
Yangtze	6,300	China	China's longest river; third longest river in the world; only the Nile and the Amazon are longer.
Zambezi	2,736	Africa	Its Victoria Falls is one of the Seven Natural Wonders of the World.

*Refers only to the length of the river itself and not the length of the river system.

Parts of a river system

A river may drain water from a huge area. The source of the river in this diagram is a melting glacier high in the mountains. But all the water that flows into the river—and the river itself—make up the parts of the river system.



water and cannot be seen. This *invisible load* mixes with lake or ocean water at the mouth. A river also carries a *visible load,* which consists of material ranging from large boulders to tiny clay particles. The finer particles in the visible load sometimes determine the colour of the river's water, which may range from red to brown or yellow. When a river deposits its visible load rapidly at the mouth, a delta forms. The Mississippi River and the Nile River have large deltas.

In dry climates, a landform similar to a delta may develop when a river flows from a steep slope to a flatter one. For example, when a river flows from a mountain slope onto a plain, the flow decreases in speed. The water then rapidly deposits its load, creating a fan-shaped land mass called an *alluvial fan.*

Some rivers have deep, broad mouths called *estuaries.* Estuaries have formed because of the tendency of most major rivers to cut their valleys to sea level. On several occasions in the past, sea level was lowered by many hundreds of metres. For example, during the Pleistocene (glacial) Epoch of geologic time, about $1\frac{3}{4}$ million to 10,000 years ago, so much water was locked up on land in the form of glacial ice that sea level was lowered. As a result, rivers cut their valleys downward to where sea level had dropped. When the glaciers melted, sea level rose again and the deep valleys and river mouths were filled with ocean water, forming estuaries. River valleys which are flooded by seawater are called *drowned valleys,* or *rias.* For example, the deep coastal inlets in southwestern Ireland and northwestern Spain are rias. *Fiords* are similar inlets of the sea, but they were formed when the sea flooded deep valleys that were carved by glaciers. The coast of Norway contains many fiords. Deep sea inlets at the mouths of rivers contain a mixture of *fresh* (unsalty) water from rivers and salt water from the ocean. The estuary of the Amazon River in South America stretches several hundred kilometres upstream from its mouth.

Related articles in *World Book.* See the *Land* section in the various country, and province articles, such as **Australia** (Land). See also:

Africa

- Congo River
- Limpopo River
- Niger River
- Nile River
- Orange River
- Ubangi River
- Zambezi River

Asia

- Amur River
- Brahmaputra River
- Euphrates River
- Ganges River
- Hooghly River
- Huang He
- Indus River
- Irrawaddy River
- Jordan, River
- Lena River
- Mekong River
- Ob River
- Sutlej River
- Tigris River
- Ural River
- Xi Jiang
- Yalu River
- Yangtze River

Australia

- Darling River
- Murray River

Europe

Aisne River
Arno River
Avon (rivers)
Clyde, River
Danube River
Dnepr River
Don River
Dvina River
Elbe River
Humber, River
Loire River
Marne River
Mersey, River
Meuse River
Moselle River
Neman River
Neva River
Oder River
Po River
Rhine River
Rhône River
Rubicon
Saône River
Schelde River
Seine River
Severn, River
Shannon, River
Somme River
Tagus River
Thames, River
Tiber River
Torne River
Tweed, River
Ural River
Vistula River
Volga River
Weser River

North America

Columbia River
Hudson River
Mackenzie River
Mississippi River
Missouri River
Niagara River
Ohio River
Rio Grande
Saint Lawrence River
Yellowstone River
Yukon River

South America

Amazon River
Madeira River
Orinoco River
Paraguay River
Paraná River
Purus River
São Francisco, Rio
Uruguay River

Other related articles

Alluvial fan
Alluvium
Basin
Bayou
Bore
Canyon
Dam
Delta
Divide
Erosion
Flood
Lagoon
Levee
Oxbow lake
Reservoir
Valley
Water power
Waterfall
World (graph: Longest river on each continent)

River dolphin is a type of dolphin that lives in fresh or slightly salty water. It inhabits warm rivers and lakes of Asia and South America.

Both river dolphins and marine dolphins belong to a group of mammals called *cetaceans.* But the two types of dolphins differ somewhat in appearance. For example, the snout of a river dolphin measures about 30 centimetres long, approximately four times as long as that of most marine dolphins. River dolphins have from 100 to more than 200 teeth. They have smaller eyes than marine dolphins, and their vision is poorly developed because they live in dark, muddy water. River dolphins are also less active than marine dolphins. River dolphins feed primarily on fish.

White fin dolphin
Lipotes vexillifer

La Plata dolphin
Pontoporia blainvillei

River dolphins live in warm rivers and lakes of Asia and South America. They have a long snout and feed chiefly on fish. Two of the four kinds of river dolphins are shown above.

The largest river dolphins grow up to 2.7 metres long, but most are smaller. The animals may be white, pink, yellow, brown, grey, or black in colour.

There are four kinds of river dolphins. The *bouta,* also called the *Amazon porpoise,* lives in rivers of northern South America. The *white fin dolphin* is found in Dongting Lake in China. The blind *Ganges dolphin* inhabits rivers of northern India and Pakistan. The *La Plata dolphin,* also known as *Franciscana,* lives in rivers and coastal waters of eastern South America. All species of river dolphins are seriously threatened by human activities that directly kill the animals or destroy their habitat.

Scientific classification. River dolphins belong to the family Platanistidae. The bouta is *Inia geoffrensis;* the white fin dolphin, *Lipotes vexillifer;* the Ganges dolphin, *Platanista gangetica;* and the La Plata dolphin, *Pontoporia blainvillei.*

See also **Cetacean; Dolphin.**

River horse. See **Hippopotamus.**

Rivera, Diego (1886-1957), was a Mexican artist who was famous for the murals he painted that portrayed Mexican life and history. Rivera was controversial because of his radical political beliefs and his attacks on the church and clergy.

Rivera was born in Guanajuato. In the 1920's, he became involved in the new Mexican mural movement. With such Mexican artists as José Clemente Orozco and David Alfaro Siqueiros, he began to experiment with fresco painting on large walls (see **Fresco**). Rivera soon developed his own style of large, simplified figures and bold colours. Many of his murals deal symbolically with Mexican society and thought after the country's 1910 revolution. Some of Rivera's best murals are in the National Palace in Mexico City and at the National Agricultural School in Chapingo, near Mexico City.

See also **Aztec** (picture); **Painting** (The 1900's).

Riverina is one of the most fertile regions in New South Wales, Australia. It lies between the Murray and Lachlan rivers and is bounded on the east by a line that extends north from Albury through Wagga Wagga to Condobolin. The central part of the region includes the Murrumbidgee Irrigation Area and the towns of Griffith and Leeton. In this area, rice, citrus fruit, peaches, and apricots grow in abundance. Good wheatlands lie to the east, and good sheeplands lie to the west. Stud sheep farms are important at Hay and Deniliquin.

Rivers, Larry (1923-), is an American painter. Beginning in the early 1950's, Rivers chose American symbols as his subjects. They were either historical themes or images of commercial products, such as cigarette packets. Rivers' deliberately unidealistic works have an amusing, ironical nature. With his introduction of popular imagery as subjects, he is often considered a forerunner of the pop art movement (see **Pop art**).

Rivers' subjects emerge from loosely painted backgrounds with visible brushstrokes or sometimes bare canvas. Many paintings have an appearance of rapid execution and fragmentation, almost as if they were unfinished. Some works show parts of the same figure from several points of view, as if it were a study sketch. Rivers was born in New York City.

Paintings by Diego Rivera portray the culture and history of Mexico. The mural on the left shows the Zapotec Indians of southern Mexico making gold jewellery before Spain conquered Mexico in the 1500's. The mural is one of a series by Rivera in the National Palace in Mexico City.

Riveting is a method of joining two metal plates with threadless aluminium, iron, or steel bolts called *rivets.* A rivet has a rounded head at one end.

In riveting, a worker called a *rivet boy* heats rivets in a small portable forge. When the rivets become red hot, the rivet boy removes them from the forge with small tongs and throws or passes them to another worker called the *holder up.* The holder up inserts the rivets in holes that have been drilled or punched in two metal plates. The rivets are long enough to extend through both plates. The holder up places an *anvil* or *bucking bar* against the rounded head of the bolt. Then another worker, called the *riveter,* uses a pneumatic hammer to close and shape the *tail,* or open end of the rivet. Rivets compressed and joined in this way become double-ended bolts that hold the plates firmly together.

Ordinarily, only one row of rivets is used. This is called *single* riveting. Riveters sometimes use *double* riveting, or two rows of rivets, when extra strength is needed. Workers can punch holes in soft metals. But they must drill the rivet holes in thick pieces or in hard metals.

Sometimes devices other than pneumatic hammers are used to shape and close rivets. Machine shops often use large hydraulic presses for riveting. A *riveting machine* has the anvil and the hammer joined together by a hinge or solid yoke. The anvil holds the rivet in place, and the hammer closes and shapes the tail.

In *cold heading,* riveters use soft iron rivets that are shaped and closed while cold. The cold forming of the soft metal increases its strength. The aircraft industry commonly uses cold heading on the aluminium wing and body surfaces of aeroplanes.

Welding has replaced riveting for many uses. But riveting is still the accepted method in making boilers and erecting structural steel for buildings. It is also necessary in shipbuilding.

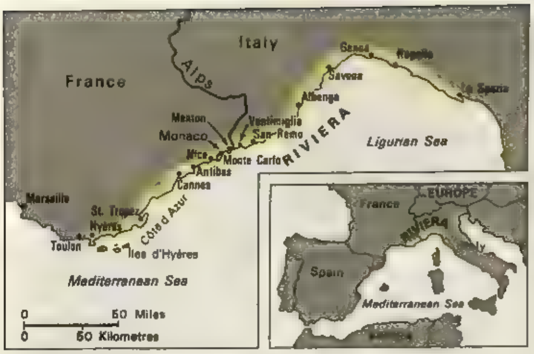
Oil painting on canvas (1953); the Museum of Modern Art, New York City

Rivers' *Washington Crossing the Delaware* shows the artist's individual approach to traditional American subjects.

Riviera is a narrow strip of land on the Mediterranean. The region runs from Hyères in southern France to La Spezia in northwestern Italy. The Alps rise at the back of the Riviera. Each year, travellers from many parts of the world bask in the warm sunshine of the Riviera for both health and pleasure. Balmy southern breezes drift in from the sea throughout the year, and the Alps shut off the cold north and east winds.

A chain of French and Italian towns lies on the Riviera. They are connected by an excellent road that follows an ancient Roman road. A railway also links the towns together. The towns are colourful with brightly painted houses and green, fragrant gardens. The people of the Riviera cultivate flowers, dates, bananas, pomegranates, and prickly pears.

The towns that are located along the Riviera include Antibes, Cannes, Hyères, Menton, Nice, and St. Tropez



The Riviera lies on Europe's Mediterranean coast.

in France; Monte Carlo in Monaco; and Albenga, Genoa, La Spezia, Rapallo, San Remo, Savona, and Ventimiglia in Italy.

See also **France** (picture); **Monaco; Nice.**

Riyadh (pop. 1,380,000) is the capital and largest city of Saudi Arabia. It lies among oases on a dry, rocky plateau near the centre of the country. For location, see **Saudi Arabia** (political map). Riyadh is the main headquarters of Saudi Arabia's vast oil industry, and thus the city has become a world business centre.

Since the mid-1900's, Riyadh has been one of the world's fastest-growing cities and much of it has been rebuilt. In the centre of the city, modern steel-and-glass buildings and wide avenues have replaced many of Riyadh's old mud-brick buildings and narrow, unpaved streets. Modern buildings also have been constructed in many other parts of the city.

Riyadh is the capital and largest city of Saudi Arabia. Oil income has made it one of the world's fastest growing cities with modern skyscrapers and wide, busy streets.

Residential areas are scattered throughout Riyadh. Many wealthy executives, representatives of foreign countries, and Saudi princes live in large, walled-in villas. Many middle-class people live in high rise flats. Some of the city's poor people live in shacks, and others live in new houses or flats that are provided by the government.

The National Archaeological Museum in Riyadh displays objects from all periods of the country's past. King Saud University in Riyadh is one of Saudi Arabia's largest universities. The city has many football stadiums and also a race track. Riyadh also has several small parks and a zoo.

The government of Saudi Arabia, which controls the country's oil industry, employs more of Riyadh's residents than any other business. The city's growing construction industry also employs a large number of workers. Factories in the city produce cement for use in the construction industry. Riyadh has many marketplaces called *suqs.* Merchants in the suqs sell fabrics and also dates, grains, and vegetables that are grown in the nearby oases.

Scholars believe that the area where Riyadh is now located consisted of several small farming settlements from as early as 700 B.C. until the A.D. 1700's. In 1746, a local leader united the settlements into a single community. In 1824, Riyadh became the capital of a state ruled by the Saudi family. It remained the capital after the nation of Saudi Arabia was formed in 1932. The city has grown rapidly since the 1950's and especially the early 1970's, as Saudi Arabia's oil income has increased. The population of Riyadh has approximately tripled since the mid-1960's.

Rizal, José (1861-1896), a Filipino doctor and novelist, became a national hero of the Philippines. He was an early leader of the Filipino movement for political and social freedom from Spain. The Spaniards, who ruled the Philippines at the time, executed Rizal for his activities. After the Philippines gained independence, the province of Rizal in central Luzon was named in his honour.

Rizal first gained worldwide notice with two novels he wrote while living in Europe during the 1880's. *Noli Me Tangere* (Latin for *Touch Me Not*) was published in Berlin in 1886. Rizal's second book *El Filibusterismo* (The Subversive) was published in Belgium in 1891. Both novels exposed the ills of the Spanish colonial government and Filipino society. Rizal wanted to awaken Filipinos to their status as subjects of Spain.

José Mercado y Alonso Rizal was born in Calamba, about 50 kilometres southeast of Manila. He was the second son of a middle class Filipino family, who leased a large rice farm from the Dominican priests. After obtaining his qualifications in medicine in Madrid, Rizal travelled to Germany, England, and France, where he continued to study medicine. He was one of the Filipino propagandists who wrote for *La Solidaridad,* a fortnightly magazine published in Barcelona, Spain, that campaigned for reforms in the Philippines.

Rizal was a man of many talents. A gifted linguist, he is said to have understood 22 languages, including French, German, Hebrew, Italian, Japanese, and Russian. He was not only a novelist but also a poet, essayist, historian, musician, painter, and sculptor. In addition, he

was an accomplished naturalist, surveyor, and sharpshooter.

While conducting research at the British Museum in London, Rizal came across an early history of the Philippines. The book was by Antonio de Morga and was printed in Mexico in 1609. Morga, one of the earliest Spanish governors general, pointed out that Filipinos had a civilization of their own before the Spanish arrived. In 1890, Rizal printed a new edition of the history with his own notes added to the text. Following this project he wrote an essay "The Philippines a Century Hence" in which he predicted that the United States would replace Spain in control of the Philippines. His prediction came true in 1898.

In 1892, Rizal returned to Manila. He was arrested and exiled to the southern Philippine island of Mindanao. There he fell in love with Josephine Bracken, an Anglo-Irish girl from Hong Kong. During his exile, Rizal drew pencil sketches of local residents and of many of his friends. One of the best was a drawing of Josephine Bracken.

In 1896, the *Katipunan,* a secret Filipino revolutionary society, tried to overthrow the Spanish government. Rizal was on his way back to Manila when the revolution broke out. Although he had no connection with the society or the uprising, a Spanish military court found him guilty of promoting the rebellion. On the morning of Dec. 30, 1896, Rizal was executed by firing squad at the Luneta, the public park in Manila where criminals were shot. The night before his death he wrote a touching poem in Spanish, bidding farewell to his beloved country. Friendly Jesuit priests convinced Rizal to sign a religious retraction that enabled him to marry Josephine Bracken shortly before his execution. After Rizal's death, Josephine Bracken joined the rebels in Cavite province, and served in the revolution as a nurse.

RLF. See Eye (Diseases of the retina).

RNA. See Nucleic acid; Cell (Producing proteins; RNA—the master copy).

Roach. See Cockroach.

Roach is a fish of the carp and minnow family that lives in fresh waters of Europe. This fish usually grows about 15 centimetres long, but it may reach a length of 30 centimetres. The roach is silvery, with a greenish back.

Scientific classification. The roach belongs to the carp family, Cyprinidae. The European roach is *Rutilus rutilus.*

Road is a strip of land that provides routes for travel by cars and other wheeled vehicles. Roads usually connect urban areas with each other and rural areas with urban areas. Roads within towns and cities are called *streets.*

Roads are vital lifelines. Farmers use them to ship their products to market. Trucks carry manufactured products from one area to another. Roads carry cars, buses, bicycles, and other vehicles on business and pleasure.

The European roach is a small, slow-swimming fish that lives in freshwater streams and rivers.

Roads and highways in Australia range from lonely outback roads, *above,* to busy freeways around cities.

Kinds of roads

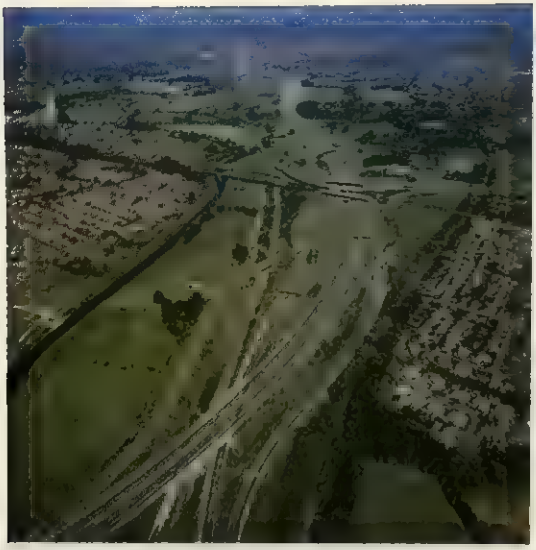
Local and secondary roads. *Local roads* carry traffic within a local area. *Secondary roads* link small communities and connect local roads to main roads leading to more distant places. Most local and secondary roads are built and maintained by local governments.

Main roads. The most important roads generally are those that carry the greatest number of cars, trucks, and buses. These main roads connect larger communities.

Some roads with four or more traffic lanes are divided in the centre with a strip of land, called a *central reservation,* often with a safety barrier. This strip separates lines of traffic going in opposite directions and helps to prevent collisions.

Another important factor in safety and smooth traffic flow is the principle of *controlled access.* On a major road, a vehicle can enter or leave the traffic flow only at certain locations called *interchanges.* These interchanges are usually located at main crossroads. To separate crossing streams of traffic, one of the intersecting roads crosses over the other on a bridge, or *fly-over.* The two are connected by sloping, curved roadways called *ramps* or *slip roads.* Minor roads and streets run over or under a major road without connecting to it.

Motorways. The biggest roads are known as *motorways, freeways,* or *expressways.* Different names for such roads are used in various countries. These major roads have four or more lanes of traffic, divided by a



The M63 motorway runs along the eastern side of Salford, in northern England. A motorway has links with many other major roads, and it has several complex junctions.

central reservation. In congested parts of big cities, motorways are often *elevated* (built above surface streets) or built in tunnels, or *underpasses,* beneath surface streets. In many countries, motorists have to pay a *toll,* or fee, to travel on motorways.

Motorways and other roads are numbered to help travellers. In Britain, for example, motorways bear the letter M, followed by a number. Lesser main roads, called *trunk roads,* bear the prefix letter A, followed by a number. Minor roads bear the prefix letter B and a number. In the Republic of Ireland, the main trunk roads radiating from Dublin are numbered consecutively in a clockwise direction. Trunk roads carry the prefix T, while link roads that connect with the T-roads are denoted by the letter L, followed by a number. Similar schemes of letters and numbers are used in most countries. These letters and numbers appear on road signs and on maps.

Warning signs on motorways alert drivers to exits, and indicate how far it is to the next service area where there are fuel, parking, and restaurant facilities. Motorways also have emergency warning signs that are switched on in bad weather, or to tell drivers to slow down when approaching roadworks or the scene of a traffic accident.

How roads are built

Planning. Road planners study everything from the long-range needs of a region or the entire country to a particular section of a single route. This planning determines what the road needs of the region are and how these needs can best be fulfilled and paid for.

Much road work is devoted to improving present roads or replacing them. In developing countries, this may mean turning a dirt road into an all-weather paved road. New roads may be needed to cope with increasing traffic, or to connect with a new town or development area.

In planning a system or a route, planners must learn: (1) where people live, (2) where they want to go, (3) how they get there, (4) where goods are produced, (5) what markets the goods are sent to, and (6) how the goods reach their final users. Traffic counts tell how many and what kinds of vehicles travel on a road, and when traffic is heaviest. From these and other facts about the past and present, planners can forecast the future. They can predict probable future growth in population and industry, changes in land use, and how such growth and change will affect highway needs.

Public participation in road planning is essential. Road planners hold public hearings on most major road projects. These meetings enable citizens to present their views before a project begins.

Road engineers have drawn up standards for various kinds of roads and bridges. These standards govern the thickness and kind of foundation and surfacing for different kinds of traffic; the number of lanes needed; the sharpness of curves; and the steepness of hills. For example, engineers agree that most road lanes should be at least 3.5 metres wide.

In planning a new road or rebuilding an existing one, maps must be drawn if they are not already available. Aerial photography is widely used today for this work. These maps show the location of other roads, railways, towns, farms, houses, and other buildings. They also show such natural features as rivers, lakes, forests, hills, and the slope of the land. The types of soil may also be identified.

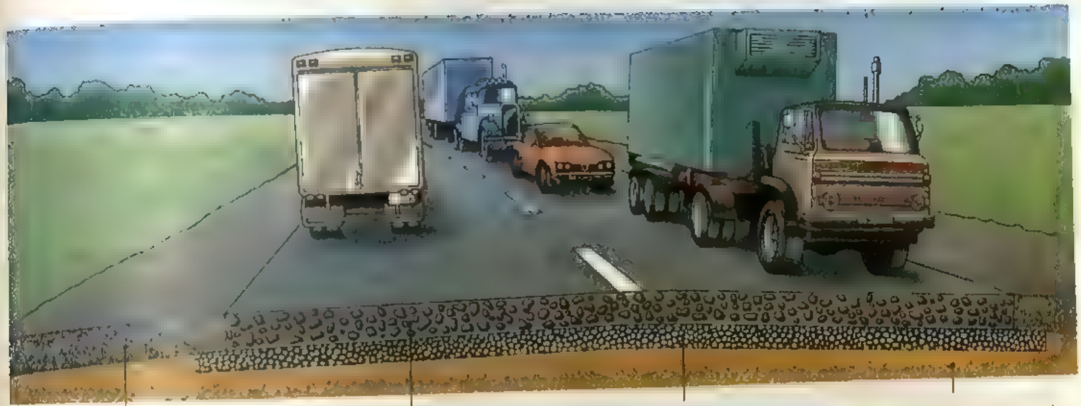
Using these maps, engineers locate new roads and make detailed drawings called *plans.* The plans show the exact boundaries of the *right-of-way.* This is land needed for road surface, shoulders, ditches, and side slopes. The plans also show the exact location, grades, and curves of the road, and the location of bridges and culverts.

Bypasses are built to take motorists around towns and cities. The bypass helps motorists to avoid city traffic, and reduces traffic congestion for those who want to drive into town.

Intersections, or *junctions,* are crossings of one road by another. Most intersections are at the same level, so that vehicles going east and west have to take turns crossing with vehicles going north and south. An alternative is a circular intersection, or *roundabout.* Sometimes roads intersect at odd angles and it is especially difficult to make a safe crossing. At such places, the traffic engineer may put *islands* in the paved area to keep traffic in the proper paths. The best and safest kind of intersection is the interchange where traffic lanes are kept apart. One common type of interchange is called a *cloverleaf,* because its curved inner ramps form the pattern of a four-leaf clover. A simpler kind is called a *diamond* because its ramps form that shape. Diamonds often connect a major road and a secondary road. When two motorways intersect, more complex interchanges are sometimes needed. These may require a number of bridges and slip roads.

Grading. The first job in building a new road is to clear the right-of-way. There may be trees to cut down and stumps to pull up. Sometimes buildings have to be torn down or moved. The right-of-way then is ready for rough grading. Here is where other big machines begin

A typical design for a paved road



Shoulders are wide for safe emergency stopping, and sloped for proper drainage. They often have an asphalt surface and a gravel or soil-cement base.

Surface, or wearing course, is smooth, firm, and water-shedding. This road has a concrete surface. Many roads have bituminous surfaces.

Base provides support for the surface and prevents moisture from forming under it. Materials include sand, stone, and bitumen or portland cement.

Subgrade is the natural soil that forms the roadbed. The soil is either naturally firm, or is levelled off and packed by heavy machines.

to work. Huge earth movers, which can dig up a roomful of dirt in one scoop, are used. They cut into the hills, carry the earth along, and drop it into the valleys to make a road with gentle gradients, or slopes.

Sometimes, the right kind of earth to be used for the foundation of the road must be hauled in, perhaps from some distance away. While the grading is going on, *culverts,* or pipes to carry away rain water, are put in place under the road. Ditches are cut at the roadsides to carry rain water to the culverts. After the right-of-way is shaped roughly for traffic lanes, shoulders, and ditches, it is smoothed and packed down to the required level and shape.

Paving begins after grading is completed. The paving is of definite thickness and is of stronger materials than the earth underneath. The kind and thickness of a paving depend largely on the weight and amount of traffic expected to use it.

In some places, different kinds of earth or soil are mixed together to form a base. Certain chemicals, lime, cement, or *bitumens* (asphalts and tars) may also be mixed with soil to act as a binder and to make it harder and more durable. On most of the low-traffic surfaced roads, however, the base is of gravel, crushed rock, or other mineral materials. This type of base may be given a thin surfacing of bitumens known as *seal coat.*

Roads that carry heavy traffic must have a durable surface. An intermediate type of surfacing is called *bituminous macadam.* This is made by placing crushed stone or gravel on the roadbed, packing it down firmly, and filling the spaces with a bitumen. Better types of bituminous surfacing are made with sand, gravel, or crushed stone premixed with bitumens. These types of surfacing are laid with a paving machine, and then rolled hard and smooth. Bituminous pavement is sometimes referred to as *blacktop.*

Another hard surfacing material is portland cement concrete. It is made with sand, portland cement, water, and gravel or crushed stone. In both kinds of surfacing—bituminous and portland cement concrete—the *aggregate* (stone and sand) forms the body of the material and the bitumen or portland cement serves as a binder.

Lighting. Good lighting helps to reduce the number of accidents for both vehicles and pedestrians. On country roads, nearly all the light comes from the headlights of the trucks and cars. But on busy streets and at dangerous locations, overhead lights are used. Street lights usually are placed on poles spaced about 60 metres apart along both sides of the road. Reflectors for the lamps are designed specifically to shine most of the light down on the roadway without glaring into the eyes of drivers.

Roadside improvement. Roadsides are often planted with special grasses or vines to prevent the earth from washing into the ditches. In addition, many roadsides are beautified with trees and bushes. Such planting and landscaping help break the monotony of travel and make the countryside more attractive. Trees also help to reduce traffic noise. At intervals along the road are service areas, picnic areas, or small *laybys* (parking places), where travellers can stop to rest or eat, or where tourists can admire a scenic view.

Tests and research. Most road testing falls into one of five groups: soils, materials, equipment, construction, or research. Soil testing is done to find out how soils change when they are dry or wet. Tests show how heavy a load the soil can support.

As roads are built, they are inspected continually and tests are made on materials being used. Even after a road is finished, drilling machines take sample *cores* out of the paving and the base. These samples are removed much as you take the core out of an apple. Cores show how thick the finished paving is. Tests on the cores also tell how strong the paving is.

How roads are maintained

Repairing damage and resurfacing. Roads gradually wear out. The work of repairing and resurfacing is

called *maintenance.* Maintenance also includes removing ice and snow, painting warning lines or stripes on the road surface, cutting grass, putting up signs, and caring for verges, roadsides, and bridges.

Gravel and other similar type roads have to be smoothed quite often. Every few years, gravel and similar surfaces require new coverings to replace the material that has blown, washed, or worn away.

Surfaces and edges of bituminous materials are repaired by patching with new material where worn spots develop from traffic use or because of weak spots in the ground underneath. Most roads that have bituminous surfaces have to have a new seal coating from time to time. Every 10 or 15 years many of them are resurfaced completely.

Concrete surfaces are repaired by digging out broken places and putting in new concrete. Cracks are often repaired by filling them with asphalt. Many older concrete pavings may be resurfaced completely. In some cases, sections, or slabs, of concrete pavement settle unevenly into the ground. These slabs have to be correctly replaced.

Clearing ice and snow. Most roads in cold countries must serve all year round. So they must be kept free from snow and ice in the winter. In some places, *snow fences* are put up. These are placed parallel to the road, on the side from which the storm winds usually blow, and about 15 to 30 metres from the road. Snowdrifts then form between the fence and the road instead of piling up in the road.

Trucks with V-shaped or straight blade ploughs attached to the front clear the roads when it starts to snow. In deep drifts, special snowploughs are needed. Some of the most powerful snowploughs are called *rotary ploughs.* Rotary ploughs have a big screw at the front which chews into the snowdrifts and pulls the snow back into a large fan. The fan shoots the snow to one side of the road.

Often roads that are slippery from ice and snow must have salt, chemicals, sand, or cinders spread on them to keep them passable.

How roads are paid for

Roads are built and maintained by local and national governments.

Local financing. Local communities pay for road building and maintenance with money from local taxes. In the United Kingdom, the government collaborates with county councils in England and Wales (region and island councils in Scotland) over improving and maintaining existing roads. The Department of Transport and the Scottish and Welsh offices pay for new motorway and A-road construction, repair, and improvement. Local authorities also help supervise motorway and A-road work at a regional level. In Northern Ireland, the Northern Ireland Department of the Environment controls road works. In the Republic of Ireland, the Department of the Environment centrally controls T- and L-road construction and repair.

In Australia, the federal government taxes petrol, but returns only a small proportion of this money to the states for roads. The states obtain most of their funds for roads from fees paid for such items as motor vehicle registrations and driving licences. Local councils pay for streets in their areas from rates paid by residents and property owners. New Zealand also finances its roads from petrol taxes, vehicle taxes, and local rates.

History of roads

The first roads. Roads are so old that historians are not sure of the origin of the word *road.* However, most experts think it came from the Middle English word *rode,* meaning *a mounted journey.* This may have come from the Old English *rad,* from the word *ridan,* meaning *to ride.*

In England, hundreds of years ago, certain main roads were higher than the surrounding ground. This was because earth was thrown from the side ditches toward the centre. Because they were higher, they were called *highways.* These roads were open to all travellers. Private roads were known as *byways.*

The first roads in the world probably followed trails and paths made by animals. These trails and paths led from feeding grounds to watering places. People followed these trails to hunt for animals. People also made their own trails and paths in searching for water, food, and fuel. Explorers followed these trails as they investigated new lands.

Early roads were built in the Middle East soon after the wheel was invented. This was about 3000 B.C. As trade developed between villages, towns, and cities, other paths, or trade routes, were made. One such early system of roads was the Old Silk Trade Route which ran over 9,700 kilometres, connecting China with Rome and pre-Christian Europe. Merchants used this ancient route to carry Chinese silk across Turkestan, India, and Persia.

Preparing the subgrade, big bulldozers scrape off the surface of the ground, clearing scrub and small trees as they go. They cut and fill in the easier places. They also smooth the big cuts and fills made by giant earth-moving machines.

The first road markers were piles of stones at intervals. Trails through forests were marked by *blazing trees*, or cutting a piece from the bark of the tree.

The Egyptians, Carthaginians, and Etruscans all built roads. But the first really great road builders were the Romans. They knew how to lay a solid base and how to give the road a pavement of flat stones. The Romans knew that the road must slope slightly from the centre toward both sides to drain off water. This gave the road a *crown*. The Roman road builders knew also that there must be ditches along the sides of the road to carry water away. Roman roads were built mainly to get soldiers from one part of the Roman empire to another. These roads ran in almost straight lines and passed over hills instead of cutting around them. The Romans built more than 80,000 kilometres of roads in their empire and some of them still are in use. See **Appian Way** (picture).

In the Middle Ages, most roads in Europe were merely clearings in the forests. There was little reason to build good roads, because most of the travel was on horseback. But a notable medieval road in England was Pilgrims' Way, which ran from Winchester to Canterbury. The coming of stagecoaches led to a demand for better roads and the passing of the Turnpike Acts. These acts established the principle of charging road users for the maintenance of the roads. Some of the roads and bridges built by General Wade in Scotland in the late 1700's remain as a tribute to his skill.

In South America from the 1200's to the 1500's the Inca Indians built a network of 16,000 kilometres of road connecting their cities.

In Europe, the one man who did more for road building than anyone else up to his time was John Loudon McAdam, a Scotsman. McAdam began building roads in England in the early 1800's. He is remembered for the surface he developed for roads. This kind of surface is called *macadam* and is used in road construction to this day. See **McAdam, John Loudon; Industrial Revolution** (Roads).

Modern roads. By 1900, there was a growing demand for good roads. Farmers and ranchers wanted roads extending a short distance to the railways so they could transport their produce and livestock to market. After 1900, with the ever-growing use of cars, trucks, and buses, the demand arose for good roads to all places. Motorway building began in Italy and Germany in the 1920's and 1930's, and was speeded up after World War II (1939-1945) to keep pace with the rapid increase in motor traffic in the developed countries. New roads were built in the developing nations of Africa and Asia as part of modernization and industrialization programmes. In many nations, such as Australia, where some roads are more than 4,000 kilometres long, construction programmes are providing hard, dustless, all-weather surfaces for all main roads.

Related articles. See the *Transportation* section in the various state, county, and country articles. See also the following articles in *World Book*:

Some roads

Alaska Highway
Appian Way
Burma Road
Oregon Trail
Pan American Highway
Simplon Pass and Tunnel
Trans-Canada Highway

Construction and maintenance

Asphalt
Bridge
Bulldozer
Cement and concrete
Easement
Electric light
Gravel
Lighting
Traffic
Tunnel
Viaduct

Other related articles

Bus
Car
McAdam, John Loudon
Police
Roman roads
Rome, Ancient (Transportation and communication)
Safety (Safety in transportation)
Telford, Thomas
Transportation
Turnpike

Road map. See **Map** (Mobility maps).

Roadrunner is a swift, ground-dwelling bird found in the scrublands of the Southwestern United States and Mexico. Roadrunners can fly, but they are most at home on the ground. They can run as fast as 24 kilometres per hour. The name *roadrunner* comes from the bird's habit of racing down roads in front of moving vehicles and then darting to safety in the scrub. Other names for the bird include chaparral cock, ground cuckoo, and snake killer.

Roadrunners measure nearly 60 centimetres in length, about half of which is tail. They have long, sturdy legs and a slender, pointed bill. The upper body is mostly brown with black streaks and white spots. The neck and upper breast are white or pale brown with dark brown streaks, and the belly is white. A crest of brown feathers sticks up on the head, and a bare patch of orange and blue skin lies behind each eye.

Roadrunners eat chiefly insects and small *vertebrates* (animals with backbones), including gophers, baby birds, mice, lizards, and snakes. They kill their larger prey by beating it against a hard object and then swallowing it whole. Roadrunners build a cup-shaped nest of sticks in a low tree or a clump of cactuses. They line the nest with leaves, grass, and other soft materials. The female lays from two to six white or yellowish eggs.

Scientific classification. The roadrunner belongs to the cuckoo family, Cuculidae. Its scientific name is *Geococcyx californianus.*

See also **Bird** (picture: Birds of North America).

Roanoke Island. See **Lost Colony.**

Roaring Twenties was the colourful decade of the 1920's. The period is most closely associated with economic changes in the United States, and widespread social changes in some European countries. It has also been called the *Jazz Age* and the *Dollar Decade.*

Economic expansion in the 1920's created booming business profits, especially in manufacturing, and a rising standard of living for many in the United States. The increased use of labour-saving machinery in factories and on farms enabled workers to produce more goods at lower prices. Many of the people who had been living in rural areas moved to cities. Changing attitudes toward foreign relations, society, and leisure revolutionized American life in the 1920's.

In 1920, the 18th Amendment to the U.S. Constitution went into effect, prohibiting the manufacture and sale of alcoholic beverages. Breaking the prohibition laws soon became fashionable. Thousands of Americans began to make their own liquor at home. Gangsters *bootlegged*

liquor (sold it illegally) from Canada, supplied it to illegal bars called *speakeasies*, and often bribed the police not to interfere.

In Europe, many people feared that morality had crumbled completely. Before World War I (1914-1918), women had worn long hair, ankle-length dresses, and long, cotton stockings. But in the 1920's, many wore short, tight dresses and rolled their silk stockings down to their knees. European women abandoned their corsets and some even wore trousers. On both continents, women cut their hair in a boyish style called the *bob* and wore flashy lipstick and other cosmetics. Couples danced cheek-to-cheek to blaring jazz music. The United States and the United Kingdom experienced the age of the *flapper* (young women who flaunted new styles of dress and unconventional life-styles).

A serious French periodical blamed that country's economic problems on France's dance craze. It argued that the nation's postwar reconstruction lagged because the French were dancing instead of working. In France and Italy, young women went out by themselves, and some got engaged to marry without seeking their parents' permission. In popular literature, sex became a common topic. Talk of Sigmund Freud's psychoanalytic theories spread from Austria to other countries.

In October, 1929, a U.S. stock market panic began. By mid-November, stock prices had plunged by 40 per cent and the stock market crash was followed by the Great Depression of the 1930's. It was a terrible price to pay for the false sense of prosperity and national well-being of the Roaring Twenties.

Europe had been dangerously dependent on American capital. Its indulgence in its own Roaring Twenties excesses unfortunately offered the European continent no solution to its fundamental economic instability.

See also **Great Depression; Prohibition.**

Roasting. See **Cooking** (Roasting).

Rob Roy (1671-1734) was a Scottish outlaw whose real name was Robert MacGregor. *Roy* is a Gaelic word meaning *red.* MacGregor became known as Rob Roy because of his red hair and ruddy complexion.

Rob Roy was born at Glengyle, near Loch Lomond. He inherited land from his father and was a nephew of a chieftain of the MacGregor clan. Rob Roy probably combined cattle trading with stealing cattle and threatening to steal his neighbours' cattle if they did not pay him money for "protecting" them.

Rob Roy participated in the Jacobite rebellion of 1715. The rebellion sought to restore the Scottish House of Stuart to the British throne after George I of the House of Hanover had gained the throne in 1714. The rebellion was easily crushed. In 1722, British authorities captured Rob Roy. He was imprisoned and sentenced to exile. But he was later pardoned. The Scottish writer Sir Walter Scott gave a romantic, fictionalized account of Rob Roy's adventures in his novel *Rob Roy* (1817).

Robbe-Grillet, Alain (1922-), French writer, literary critic, and film director, laid the groundwork for the New Novelists in French literature.

In his essays he argued for a *nouveau roman* (new novel), also called the "antinovel." He opposed writing that rested on *preordained ideas* (ideas decided in advance) and on orderly plots, defined characters, and authors' explanations of events. In contrast, the new novels mix time, place, and points of view. They often describe things in great detail. They blur differences between the *subjective* (what a person might think) and the *objective* (what actually exists).

Such approaches, rooted in uncertainty, can confuse the reader and obscure understanding. Critics point out, however, that reality in life is often unclear and confusing. The new novel forces readers to create their own response to events depicted.

Robbe-Grillet's novel *Les Gommes* (1953), about a murder, was translated into English as *The Erasers* (1953). His works, including *Towards a New Novel* (1963; English translation 1965), have been translated into many languages. *Le Voyeur* (1955), a novel, won the French Critics Prize. He wrote the screenplay for *Last Year at Marienbad,* a controversial film that won the grand prize at the Venice Film Festival (1961).

He was born in Brest, France, and studied at the National Institute of Agronomy. After he graduated in 1944, he worked as a statistician for a government agency in Paris. He later became literary director for the Paris publisher of his and other *avant-garde* (new and experimental) literary works.

Robben Island lies in Table Bay, off the coast of Western Cape, South Africa. The island is only 3 kilometres long and 1.5 kilometres wide.

Originally a haven for seals and seabirds, Robben Island became the site of a maximum security prison. Jan van Riebeeck, commander of the first European settlement at the Cape, first sent convicts there in 1658. African National Congress leaders Nelson Mandela and Walter Sisulu were among the island's most famous political prisoners in the 1960's.

In 1995, Robben Island ceased to function as a prison and the island became a nature reserve. It is especially noted for its arum lilies. The name *Robben* is a Dutch word meaning *seals.*

See also **Western Cape.**

Robber crab. See **Hermit crab.**

Robbery means stealing money or goods from a person by force or threats of immediate force. It is a serious crime, punishable by imprisonment. The value of the property taken has little influence in determining the legal penalty, so long as the property is of value to its owner. Robbery with a gun is usually considered more serious than simple robbery.

Robbery occurs only when a thief uses force or threats to obtain something from a person. The crime of stealing a person's possessions without using force or threats is normally called *theft. Burglary* is the act of entering a building without permission for the purpose of committing a crime.

See also **Bandit; Burglary; Pirate.**

Robbia, Della. See **Della Robbia.**

Robbins, Jerome (1918-), is an American dancer and *choreographer* (dance composer). He became well known to dance audiences in 1944, when he created his first ballet, *Fancy Free.* He achieved more widespread fame as the director and choreographer of many Broadway musicals, including *The King and I* (1951), *West Side Story* (1957), and *Fiddler on the Roof* (1964). In these musicals, he blended the acting, singing, and dancing into a unified work of art. He again began to focus primarily on the ballet with his creation of *Les Noces* in 1965.

Many of Robbins' ballets are based on American subjects. Others are abstract in nature and modern in style. They often include jazz rhythms.

Robbins was born in New York City. He was a member of Ballet Theatre from 1940 to 1948 and associate artistic director of the New York City Ballet from 1949 to 1959. Robbins assumed the position of ballet master with the New York City Ballet in 1969 and was appointed ballet master in chief in 1983. He resigned from this position in 1990.

Robert. See **Kings and queens of Britain and Ireland** (The Stuarts in Scotland).

Roberts, Samuel (1800-1885), was a Welsh radical reformer. As pastor of some independent chapels in North Wales, Roberts opposed the power of the landlords, heavy taxation, and the legal disabilities of *Nonconformists* (those who refused to be members of the Church of England). Roberts was an ardent pacifist. In 1843, he became editor of the popular monthly paper *Y Cronicl* and became widely known by his initials, S.R. He led a group of emigrants to the United States in 1857, but, after 10 years, the venture failed and he returned to Wales.

Roberts, Tom (1856-1931), an Australian landscape painter, founded Australian impressionism. He also led the group of artists known as the *Heidelberg School.* From 1881 to 1885 he studied impressionism in Europe. The subjects of Roberts' most famous works included shearing sheds and sheep station incidents. His painting *Bailed Up* is now in the Art Gallery of New South Wales. Roberts established the blue and gold palette so extensively used by his followers in later years. Roberts was commissioned to paint the opening of the first federal Parliament in 1901. He worked three years on this painting. Roberts was born in Dorchester, England.

See also **Australian art; Heidelberg School.**

Robertson, Sir Dennis (1890-1963), an English economist, played an important part in organizing the Bretton Woods Conference. It set up the World Bank in 1944. Robertson's investigation into the relationship between money supplies and savings, *Banking Policy and the Price Level* (1926), anticipated the later work of Lord Keynes (see **Keynes, John Maynard**). Robertson was born at Lowestoft, in Suffolk, England, and educated at Eton College and Cambridge University. He was knighted in 1953.

Roberval, Sieur de (1500?-1560?), was one of the first French explorers and colonists in Canada. King Francis I made him a viceroy and lieutenant general of Canada in 1541. Roberval organized a colonizing expedition, followed Jacques Cartier to Canada, and landed in Newfoundland in 1542 with about 200 colonists. Roberval proceeded up the Saint Lawrence River, and spent the winter at Charlesbourg Royal (now a suburb of Quebec). After months of hardships, Roberval returned to France in 1543 with the few surviving colonists. Later, he again tried his luck, but without success. He was murdered in 1560 or 1561. Roberval's real name was Jean François de la Rocque.

Robeson, Paul (1898-1976), was a black American singer, actor, and political activist. Robeson was born in Princeton, New Jersey. He attended Rutgers University, where he starred in sports.

In 1923, Robeson earned a degree from the Columbia University Law School. He then began a long and successful career as an actor and singer. He performed throughout the world on the stage and on radio and made many films and gramophone records. Robeson gained international acclaim for his performances in such plays as *Othello* and *The Emperor Jones.* He also won praise for his moving interpretations of black spirituals and the folk music of many countries.

Paul Robeson

In the late 1930's, Robeson became involved with national and international movements for peace, racial justice, and better labour conditions. He also supported independence for African colonies from their European rulers. This involvement, his friendship with the Soviet Union, and his association with Communists brought strong opposition from conservative groups in the United States. In 1950, the U.S. government cancelled Robeson's passport. Although his musical and theatrical career declined sharply as the result of opposition, he continued his political work.

In 1958, Robeson regained his passport and moved to London, where he resumed his acting and singing career. He returned to the United States in 1963 because of ill health and lived there in retirement until his death. Robeson described his political beliefs in a book called *Here I Stand* (1958).

See also **Shakespeare, William** (picture: *Othello*).

Robespierre (1758-1794) was the most famous and controversial leader of the French Revolution (1789-

Robespierre arrested in the Convention during the French Revolution. Robespierre was injured, perhaps accidentally, by a pistol shot. On the following day he was executed.

1799). In the name of democracy, he helped bring about the Reign of Terror, a period in which thousands of suspected opponents of the revolution were executed. In time, Robespierre met the same fate.

Maximilien Robespierre was born in Arras, France. He studied at the College of Louis-le-Grand in Paris and later became a successful lawyer. Robespierre was greatly influenced by the philosopher Jean Jacques Rousseau, who argued that the right to govern came from the people.

In 1789, Robespierre was elected to the Estates-General, an assembly that the king called to deal with a financial crisis in France. There, he distinguished himself as a spokesman for the principle of equality and the rights of the common people. He wanted voting rights extended to all the people, including Protestants, Jews, and free blacks of the French colonies. Robespierre was a leader of the Jacobin Club of Paris, a radical political group. By 1792, most Jacobins wanted a democratic republic instead of a constitutional monarchy.

Revolutionary leader. In August 1792, the people of Paris took custody of King Louis XVI and his family and imprisoned them. Soon afterward, Robespierre was elected to the National Convention, a national assembly established to take over the government of France. The Convention declared France a republic, placed Louis XVI on trial, and sentenced him to death as a traitor. Robespierre then led an attack in the Convention against moderate deputies known as the Girondists. He and his followers expelled the Girondists in June 1793 and took control of the Convention.

In July 1793, Robespierre was elected to the Committee of Public Safety, the Convention's governing body. He stressed the republic's need for a single centre of opinion and viewed disagreement with the committee's policies as treachery. His speeches justified the Reign of Terror to defend and "purify" the revolution. By the end of July 1794, about 17,000 rebels and suspected "enemies of the republic" had been executed, including Robespierre's one-time friend and fellow deputy, Georges Danton.

His death and role. As a result of his policies, many members of the Convention became Robespierre's enemies. They feared for their lives and organized a plot against him. On July 26, 1794, Robespierre seemed to call for an end to the use of terror, but he also threatened unnamed deputies. The next day, a group of his opponents persuaded the Convention to order his arrest. The Convention sentenced him to die on the guillotine. He was executed on July 28, 1794.

Today, historians still argue over Robespierre's role. Some scholars regard him as cold-blooded, fanatical, and self-righteous. Others view him as "The Incorruptible," a totally dedicated patriot and democrat.

Related articles in *World Book* include:

Danton, Georges Jacques
Estates-General
French Revolution
Girondists
Guillotine
Jacobins
Louis (XVI)

Robey, Sir George (1869-1954), was one of the greatest English music hall stars. He was famous for his patter, impromptu remarks, songs, and character sketches such as "The Prehistoric Man." During World War I (1914-1918), he took part in the revue *The Bing Boys Are Here,* which included the song "If You Were the Only Girl in the World." His own revue *Bits and Pieces* was popular in the United Kingdom and on tour. In 1935, he gave a brilliant performance as Falstaff in Shakespeare's *Henry IV, Part I.* Robey was born in London and named George Edward Wade. Prior to 1891, when he made his first stage appearance, he worked as a clerk in a Birmingham tram company. Robey was often billed during his music hall career as the "Prime Minister of Mirth."

George Robey

Robin is the name of a small, European, thrushlike bird with a red breast. The name is also given to other birds with similar colouring, such as the North American robin, the Indian robin, and the scarlet robin of Australia.

The *European robin* is a small, attractive bird that grows up to 14 centimetres long. It has a red breast. The upper parts and tail are brown, and the underparts are white. In mainland Europe, the robin lives in woodland thickets. In the United Kingdom however, it is found in parks and gardens and is noted for its tameness. It follows people who are digging in gardens, and picks up insects or worms from overturned soil.

Robins often nest in ivy or other creepers on trees and walls. In gardens, they will nest in disused sheds, plant pots, or other suitable containers. They form a shallow, cup-shaped structure from grass stems, roots, twigs, rags, string, or paper. They use mud to hold the nest together. Then they line it with dry grasses. Robins are very aggressive toward other robins.

The European robin lives throughout Europe. It is about half as large as the American robin. Both the female and the male have the same colours, but the female is smaller.

Young robins have a brown speckled plumage. The robin has a sweet, warbling song and a loud, penetrating "tic tic" alarm call.

The *North American robin* is a large thrushlike bird about 25 centimetres long. It lives in open areas and feeds mainly on fruit. It also eats insects and worms. The *Indian robin* has black plumage with white shoulder patches and a reddish breast. It is a common bird of open country, including cultivated areas, throughout India and Pakistan. A lively bird, it is usually seen hunting for insects on the ground with its tail cocked up. It nests in holes in walls, earthmounds or crevices among a pile of boulders. It grows to a length of 16 centimetres. The *scarlet robin* lives in southern Australia and Tasmania. It is 11 centimetres long with a red breast and a black throat. All Australian robins belong to the flycatcher group of birds.

Scientific classification. Robins belong to the family Muscicapidae. The European, American, and Indian robin belong to the thrush subfamily Turdinae. The European robin is *Erithacus rubecula.* The American robin is *Turdus migratorius.* The Indian robin is *Saxicoloides fulicata.* The scarlet robin belongs to the flycatcher subfamily Muscicapinae. The scarlet robin is *Petroica multicolor.*

Robin Hood was a legendary English outlaw who stole from the rich and gave to the poor. He is the subject of countless ballads and stories that date back to the 1300's. He is one of the most popular English folk heroes, a symbol of independence from oppressive authority. He treated poor people kindly and fought the sheriff of Nottingham, a corrupt official who persecuted the poor. Robin Hood thus became a hero of the common people and a symbol of "right against might."

According to legend, Robin Hood lived with his merry band of followers in Sherwood Forest in Nottinghamshire during the 1100's. His best-known companions included Friar Tuck, Little John, and Maid Marian. Friar Tuck was a fat, jolly priest. Little John stood more than two metres tall and was known for his great skill with a bow and arrow. Maid Marian was Robin Hood's sweetheart, whom he treated with formal politeness.

Detail of an oil painting on canvas (1917) by N. C. Wyeth

Robin Hood and his men were legendary English outlaws who lived in Sherwood Forest. Stories claim that he and several of his followers were expert marksmen with a bow and arrow.

No one knows whether the character of Robin Hood was based on a real person. According to one traditional story, he was a yeoman. Another tradition says that he was actually the Earl of Huntingdon, outlawed for his part in Simon de Montfort's rebellion in 1265, and that his real name was Robert Fitzooth. But many scholars believe Robin Hood is a fictitious character.

The oldest written reference to Robin Hood appears in the *Vision of Piers Plowman,* a long poem written about 1378. But Robin Hood was probably the subject of many earlier folk tales that had been handed down from one generation to the next. The first detailed description of his activities was the *Lytell Geste of Robin Hood* (about 1495). Robin Hood also appears as the character Locksley in *Ivanhoe* (1819), by the Scottish novelist Sir Walter Scott.

Robinson, Edwin Arlington (1869-1935), an American poet, became best known for short poems in which he presents character studies. Three of his 13 volumes of poetry won Pulitzer Prizes—*Collected Poems* in 1922, *The Man Who Died Twice* in 1925, and *Tristram* in 1928.

Robinson's characters are citizens of the imaginary community of Tilbury Town. Among the most familiar characterizations are those in "Richard Corey," "Miniver Cheevy," "Flammonde," and "Mr. Flood's Party." In these poems, the characters seem doomed to failure and suffering. Yet Robinson was not a pessimistic writer. He indicated clearly that his characters suffer because they ask too much from life and themselves.

Robinson's continuing theme of the need for humility and complete self-honesty also appears in his philosophical poem "The Man Against the Sky" (1916). Robinson also wrote long narrative poems. *Merlin* (1917) and *Lancelot* (1920), along with *Tristram,* form a connected series telling the legends of King Arthur.

Robinson was born in Head Tide, Maine, U.S.A. Through the assistance of President Theodore Roosevelt, who admired his poetry, Robinson became a clerk in the New York Custom House in 1905. Robinson resigned in 1909 to devote himself to writing.

Robinson, George Augustus (1788-1866), a Methodist lay preacher and former bricklayer, tried in vain to save the last of the tribal Tasmanian Aborigines.

Robinson was born in London. In 1824, he emigrated to Van Diemen's Land (now Tasmania). At about this time, many more settlers were arriving to farm and cut timber. Conflict between the tribal Aborigines and these white settlers increased to the extent that Governor George Arthur declared war on the Aborigines in 1828. Any Aborigine seen in settled districts was arrested or shot, and many were killed.

Between 1829 and 1834, Robinson attempted to persuade the remaining tribal Aborigines to leave their land. In the end, Robinson was forced to capture the Aborigines at gunpoint.

In all, Robinson collected only 135 survivors from the Tasmanian mainland where, within 31 years of settlement, nearly 4,000 Aborigines had been killed. The land that had been promised to them was in fact the Wybalenna Settlement on Flinders Island, where the Aborigines were to be "civilized" and Christianized. But

under the command of Robinson, the Aboriginal people at Wybalenna declined rapidly. Disease, hunger, and despair led to the deaths of nearly half of these people in their first few years at Wybalenna.

In 1839, Robinson and 15 Aborigines moved to Port Phillip in Victoria, where he became Protector of the Aborigines. In December 1849, his post was abolished. He later returned to England.

See also **Lanney, William; Truganini; Tasmanian Aborigines.**

Robinson, Joan Violet (1903-1983), was an English economist whose theories have significantly influenced economic thought. She was a leader of the school of Keynesian economics in the United Kingdom, which follows the doctrines of the English economist John Maynard Keynes (see **Keynes, John Maynard**).

Robinson helped Keynes develop his doctrines, which revolutionized economic policy during the 1930's. Like Keynes, she believed that government spending could prevent depressions and widespread unemployment. Robinson extended Keynesian concepts to such long-term issues as economic growth and technical change.

Robinson believed capitalist systems were unstable because of conflicts between business and labour over each other's share of income. She proposed that government policies be established to determine the distribution of income between the two groups.

Robinson was born near London. She graduated from Cambridge University in 1925, and she served as a professor of economics there until 1973. She wrote many books, including *The Economics of Imperfect Competition* (1933), *Marxian Economics* (1952), and *Economic Heresies* (1971).

Robinson, Lennox (1886-1958), was an Irish dramatist and author. He was director of the Abbey Theatre, Dublin, from 1909 to 1956. Robinson wrote 20 plays for the Abbey Theatre, beginning with *The Clancy Name,* in 1908, and including *The Whiteheaded Boy,* in 1916. He was most successful with comedies about Irish country life. His other works include two books on the theatre, *An Appreciation of the Theatre* (1945) and *Ireland's Abbey Theatre (1899-1951)* (1951). Robinson was born at Douglas, in Cork.

Robinson, Mary (1944-), became the first woman president of the Republic of Ireland in 1990. She studied law at Trinity College, Dublin, at King's Inns, Dublin, and at Harvard University. In 1969 Robinson became Trinity's youngest-ever law professor. As a successful and controversial barrister, she gained a reputation for her socialist and feminist views, speaking on women's rights and marital issues. She also became an expert on European Community law.

Robinson was born in Ballina, County Mayo. Her political career started with her election to the Irish Senate in 1969. She served until 1989, as a member of the Labour Party. Robinson resigned from the Labour Party in November, 1985, because she disagreed with the party's opposition to the Anglo-Irish Agreement (see **Anglo-Irish Agreement**).

Robinson, Ray (1926-), was prime minister of Trinidad and Tobago from 1986 until 1991. His party, the National Alliance for Reconstruction (NAR) won a landslide victory over the People's National Movement (PNM), which had formed the country's government for the previous 30 years. The NAR won 33 of the 36 seats in the House of Representatives. In the 1991 election the NAR's number of seats in the House of Representatives dropped to 2.

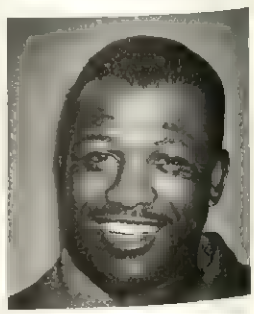
Arthur Napoleon Raymond Robinson was born in Calder Hall, Tobago, where his father was a headmaster. He received his early education in Tobago before going to the United Kingdom, where he studied at St John's College, Oxford, and later qualified as a barrister in London.

He helped to found the PNM Party in 1956. From 1958 to 1961, he was a member of the federal parliament. From 1961 to 1971, he was a member of the House of Representatives. During this time, he served as minister of finance from 1961 to 1966 and as minister of external affairs in 1967 and 1968. In 1970, he resigned from Cabinet and from the PNM Party. During the early 1970's, he worked for the Foundation for the Establishment of an International Criminal Court. From 1976 to 1980, he was a member of the House of Representatives. The NAR, founded in 1985, elected Robinson as its first leader.

Robinson, Sir Robert (1886-1975), an English organic chemist, received the 1947 Nobel Prize for chemistry. He found the structure and behaviour of many important natural substances, including the red and blue pigments of flowers; alkaloids, such as morphine and strychnine; hormones; and penicillin. Robinson also developed methods for producing many of these substances artificially.

Robinson was born near Chesterfield, England, and served as professor of organic chemistry at Sydney (Australia), Liverpool, Manchester, St. Andrews, and London universities. In 1929, he became a professor at Oxford University.

Robinson, Sugar Ray (1921-1989), won fame as one of the greatest boxers in history. He got his nickname, "Sugar Ray," after a sportswriter described him as "the sweetest fighter . . . sweet as sugar." Robinson held the welterweight title from 1946 to 1951 and then won the middleweight championship five times.



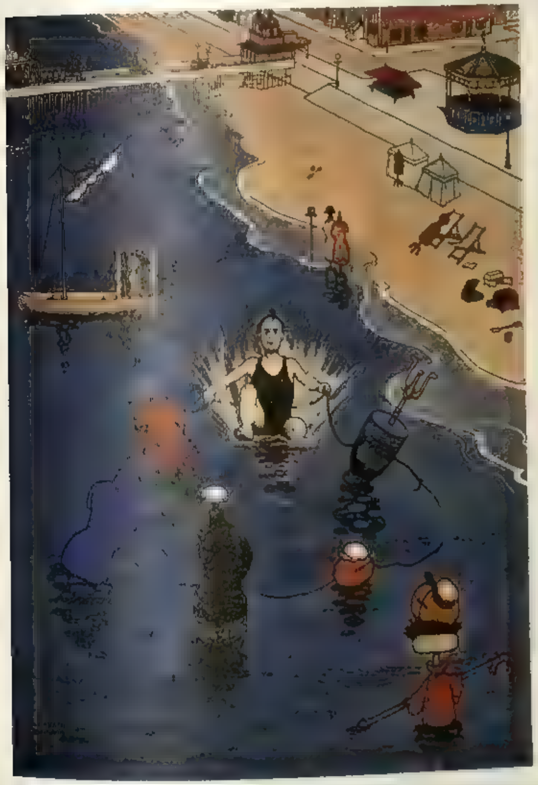
Sugar Ray Robinson

Robinson defeated Jake LaMotta in 1951 to win his first middleweight title. That same year he lost it to Randy Turpin and then won it back. He retired as champion in 1952 but returned to the ring in 1954. In 1955, he regained the title by defeating Bobo Olson. Gene Fullmer won the title in 1957. Robinson won it back and lost it to Carmen Basilio that same year. In 1958, he again regained the title. In 1959, the National Boxing Association stripped Robinson of the title because he failed to defend it within a year. But he retained the New York State Athletic Commission version of the championship, losing that title to Paul Pender in 1960. Robinson retired from boxing in 1965. He had won 175 of his 202 professional fights, 110 by knockouts.

Robinson was born in Ailey, Georgia, U.S.A. He grew up in New York City. He was born Walker Smith, Jr.

Robinson, William Heath (1872-1944), was an English artist, cartoonist, and illustrator. His work ridiculed the machine age. Many of his imaginative designs show complicated machines for performing such simple daily functions as raising one's hat.

Robinson was born in London and educated at the Islington School of Art and the Royal Academy Schools. He illustrated his first book, *Don Quixote,* in 1897. Other books illustrated by him include *The Arabian Nights* and *The Water Babies.*



A Heath Robinson cartoon shows the artist's inventiveness and humour. This picture is titled: *Frantic efforts to amuse himself and relieve his loneliness by the last man left at the seaside.* He has created companions from dressmakers' dummies and a broomstick.

Robinson Crusoe is an imaginary story about a merchant-adventurer who is marooned on a desert island. Daniel Defoe wrote this novel in 1719. He based the story partly on the experiences of a Scottish sailor, Alexander Selkirk. But Defoe's realistic account of Crusoe's life on the island is much more interesting, and has become one of the most popular books in English.

The book explains how Crusoe cleverly manages to make himself comfortable while he lives on the island. After living alone for 26 years, Crusoe rescues a man from cannibals. He calls the man *Friday* because he met him on that day. Friday becomes Crusoe's trusted friend and servant. The term, "man Friday," has come to mean any trusted servant. Finally, after 28 years, Crusoe and Friday board a passing ship and are taken to England.

See also **Defoe, Daniel; Selkirk, Alexander.**

Robots efficiently perform a wide variety of tasks that are boring, difficult, or dangerous for people, including welding car body parts, *above,* and assembling electronic circuits.

Robot is a mechanical device that operates automatically. Robots can perform a wide variety of tasks. They are especially suitable for doing jobs too boring, difficult, or dangerous for people. The term robot comes from the Czech word *robota,* meaning *drudgery.* Robots efficiently carry out such routine tasks as welding, drilling, and painting car body parts. They also produce plastic food containers and wrap ice cream bars. Some industrial robots can even assemble electronic circuits and watches. The science and technology that deals with robots is called *robotics.*

A typical robot performs a task by following a set of instructions that specifies exactly what must be done to complete the job. These instructions are entered and stored in the robot's control centre, which consists of a computer or part of a computer. Robots vary in design

Illustration from *Robinson Crusoe* by Daniel Defoe illustrated by N. C. Wyeth

Robinson Crusoe, after being shipwrecked and stranded on an island, uses a telescope to examine his surroundings.

and size, but few resemble the humanlike machines that appear in works of science fiction. Most robots today are stationary structures with a single arm capable of lifting objects and using tools. But engineers are developing mobile robots equipped with television cameras for sight and electronic sensors for touch. These robots are controlled by both stored instructions and feedback they receive from the sensors. Such robots might be used for sea-floor and planetary exploration or some other scientific research.

See also **Automation; Čapek, Karel; Computer.**

Robson, Dame Flora (1902-1984), was an English dramatic actress. She made her stage debut at the Shaftesbury Theatre, London, in 1921. From 1931 to 1939, she appeared in nearly 30 plays, mainly in London. During the 1940's, she worked for a time in the United States in both plays and films. She returned to the London stage in 1950 and made several tours during the 1950's and 1960's. She later appeared in television serials, including *Heidi* (1974). Her many films include *Catherine the Great, Wuthering Heights, Caesar and Cleopatra, Romeo and Juliet, 55 Days at Peking,* and *Murder at the Gallop.* Flora Robson was born in South Shields, Tyne and Wear, England. She trained at the Royal Academy of Dramatic Art, in London. She became a Dame of the British Empire in 1960.

Robusti, Jacopo. See **Tintoretto.**

Roc was a mythical bird of enormous size, known from the stories in the *Arabian Nights.* It resembled an eagle, but was large enough to seize an elephant in its talons. In the *Arabian Nights,* Sinbad the Sailor tells of seeing the roc's gigantic egg. The bird was assumed to live on the island of Madagascar. Marco Polo heard the people of the island report that at a certain season of the year the bird appeared from the south. See also **Elephant bird.**

Rocha, Glauber (1938-1981), a Brazilian film director, was noted for inventive films about Brazilian culture and society. He was a leading figure in the 1960's Brazilian movement *cinema novo* (new cinema).

Glauber Andrade Rocha was born in Vitória da Conquista, Bahia, Brazil. He worked as a journalist and critic before becoming a film director. His films include *Deus e o Diabo na Terra do Sol* (*Black God—White Devil,* 1964) and *O Dragão da Maldade contra o Santo Guerreiro* (*The Dragon of Evil Against the Holy Warrior,* 1969). Both films portray outlaws and religious prophets. *Terra em Transe* (*Land in Trance,* 1967) is a discussion of middle class intellectuals and politicians. Rocha's films were praised by Brazilian and European critics. But he was criticized by conservatives in the Brazilian government. Rocha left Brazil in 1970 to work in Europe. In 1976, he returned to Brazil where he filmed *Di* (1977), an unconventional documentary about the death of the Brazilian painter Emiliano Di Cavalcanti.

Rochambeau, Comte de (1725-1807), a French general, went to America in 1780 with French troops to serve under General George Washington in the American Revolution. In 1781, he helped plan the Battle of Yorktown and the defeat of Lord Cornwallis.

Rochambeau was born in Vendôme, the younger son of a French noble. His full name was Jean Baptiste Donatien de Vimeur. He studied for the priesthood. But, in 1742, he began a long and distinguished career as a soldier. Rochambeau's bravery and skill in the War of the Austrian Succession and Seven Years' War won him steady advancement. As inspector-general of the army, Rochambeau made many important military reforms later used successfully during the French Revolution and by Napoleon. On his return from America in 1783, Rochambeau was appointed governor of Picardy and Artois. He served in the French Revolution, and was promoted to Marshal of France in 1791. Imprisoned during the Reign of Terror, Rochambeau narrowly escaped being executed. Napoleon later restored Rochambeau's rank and granted him a pension.

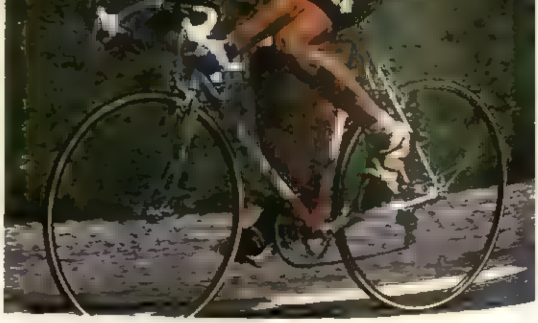
Comte de Rochambeau

Rochdale (pop. 196,900) is a local government district in Greater Manchester, England, centred on the town of Rochdale. The district also includes the towns of Heywood and Middleton. Textile production is a traditional industry. Other industries include warehousing and distribution, and making asbestos and plastics goods. See also **Manchester, Greater.**

Roche, Stephen (1959-   ), an Irish cyclist, won the Tour de France race in 1987. Many people consider the race to be the world's most important cycling event. Roche was placed third in the event in 1985. He also won the Tour of Italy in 1987. Roche was born in Dublin, and started his cycling career there. He worked as a central heating technician while cycling as an amateur rider. In 1979, Roche moved to France, where he turned professional in 1981.

Rochelle salt. See **Tartaric acid; Salts.**

Rochester, Earl of (1647-1680), was a poet of the Restoration period in England noted for his love poems and biting satires. John Wilmot, second Earl of Rochester,



Stephen Roche, an Irish cyclist, riding to win the 1987 Tour de France. In the same year he won the Tour of Italy.

was a colourful figure at the court of King Charles II, from which he was frequently banished for his wild, unruly living.

Rochester upon Medway (pop. 142,000) is a local government district in Kent, England. It is administered from the historic cathedral city of Rochester, located on the River Medway. The district's other main town is Chatham, formerly important for its Royal Navy dockyards. Rochester upon Medway contains the flat, low-lying Hoo peninsula, which includes the Isle of Grain. The chief industries include boat building, engineering, printing, and sawmilling. Rochester's cathedral is Norman in style. The keep of Rochester Castle dates from the 1100's. See also **Kent**.

Rochford (pop. 74,000) is a local government district in the English county of Essex. It is a mainly residential area. Many people who live there work in Southend and London. The district occupies low-lying fertile land between the estuaries of the rivers Thames and Crouch. Mixed farming and commercial fishing are important aspects of the local economy. Industries include brick making, flour milling, boat building, and toy making. The district includes the ancient towns of Rochford, the administrative centre, and Rayleigh. Rayleigh shows evidence of Roman occupation, and Rochford is mentioned in the Domesday Book. Foulness Island is a bird sanctuary. See also **Essex**.

Rock is the hard, solid part of the earth. In many areas, the rock is covered by a layer of soil in which plants or trees may grow. Soil itself is made up of tiny bits of rocks usually mixed with organic materials from plants and animals. Rock also lies beneath the oceans and under the polar icecaps.

Where roads cut through hills, you can often see layers of rock in the exposed hillsides. Many rivers cut deep channels through rock to form canyons. Great cliffs of rock line the seashore in such places as northwestern and southern Australia, and Norway. In desert regions, rock cliffs and pinnacles may rise high above the sandy plains.

Most rocks are *aggregates,* or combinations, of one or more minerals. Basalt, for example, contains crystals of the minerals plagioclase and pyroxene. In some cases, the minerals are so small that the rocks appear to be dense and massive, with no mineral grains. But if you examine a very thin slice of such rock under a microscope, you can see grains of minerals.

Rocks and minerals are useful to us in a number of ways. Builders use granite, marble, and other rocks in construction work. Cement made from limestone and other rocks serves to bind crushed stone into strong, long-lasting concrete for buildings, dams, and roads.

Metals such as aluminium, iron, lead, and tin come from rocks called *ores.* Ores also supply such radioactive elements as radium and uranium. Ore deposits may lie close to the earth's surface, or deep underground. In some regions, deposits of iron or copper ores make up entire mountains.

Some rocks contain valuable nonmetallic minerals such as borax and graphite. All gems, with the exception of amber, coral, and pearl, come from rocks. Diamonds mined in Africa and Arkansas, U.S.A., come from a rock called *peridotite.* Emeralds are found in black limestone in Colombia.

Geologists trace the history of the earth by studying rocks (see **Geology**). They find oil deposits by studying the structure, age, and composition of rock layers. Other scientists study *fossils* (remains of plants and animals found in rock) to learn about the kind of life that existed millions of years ago (see **Fossil**). Geologists have developed precise methods for finding the age of rocks by measuring the amounts of radioactive atoms in rocks. Each radioactive *isotope* (type of atom) disintegrates at a constant rate. By measuring the proportion of radioactive atoms of an isotope in a rock, geologists can tell when the rock was formed (see **Radioactivity** [Half-life]).

Thousands of young people and adults enjoy collecting rocks and minerals as a hobby. They trade rocks and minerals just as stamp collectors trade stamps. A collector in Sydney may trade with fellow enthusiasts in his or her local rock and mineral club, or with other collectors as far away as New York City, London, or Vienna. There are rock and mineral clubs in many parts of the world. These clubs hold regular meetings, sponsor study groups and exhibits, and organize field trips to collecting areas. Sometimes rock and mineral clubs help develop collections for local museums.

The three main kinds of rocks are: (1) igneous rocks, (2) sedimentary rocks, and (3) metamorphic rocks.

Igneous rock

Deep within the earth there exists *molten* (melted), rock material called *magma.* Magma is under great pressure and is extremely hot (750° to 1250° C). This hot material sometimes rises to the earth's surface through *fissures,* or cracks, caused by earthquakes and other deep movements of the earth's crust. Or, the intense heat and pressure of the magma weakens the rocks above it until they give way. *Igneous rocks* form when magma cools and solidifies. Scientists divide igneous rocks into two groups: extrusive and intrusive.

Extrusive rocks form when magma is *extruded,* or forced out, onto the surface of the earth. The magma emerges as streams of molten rock, as partially solid masses of hot lava, or as fine cinders and ash. When lava piles up and hardens around a fissure, it forms a volcano.

Exposure to the cooler surface temperatures causes the lava to harden in a few hours. The minerals it contains do not have time to form large crystals. It may harden so quickly that it forms *obsidian,* a smooth, shiny *volcanic glass; pumice,* a finely porous rock frothy with air bubbles; or *scoria,* a rough rock that looks like furnace slag. Lava that hardens more slowly forms rocks with tiny mineral crystals in them. These *finely crystalline* rocks include dark-coloured *basalts* and light-coloured *felsites.*

Sometimes a volcano throws lava into the air with great violence. The masses of lava form lumps of rock that range in size from tiny particles of *volcanic dust* to *volcanic bombs* more than 30 centimetres in diameter. Pieces bound together by natural cement are called *agglomerate* rocks or *volcanic breccias.*

Intrusive rocks form from magma that does not rise all the way to the surface of the earth. It may push up the surface rock in the shape of a huge blister. Sometimes it spreads out in sheets between layers of older rocks. The magma may also melt surrounding rocks to create an

opening for itself. Beneath the surface, the molten rock cools and hardens slowly. Rocks formed in this way have coarse mineral grains that can be seen with the unaided eye. These *coarsely crystalline* rocks include the *granites, syenites,* and *gabbros.*

Sedimentary rock

Sedimentary rock consists of materials that once were part of older rocks or of plants and animals. These materials accumulate as *strata* (layers) of loose material. Most of the deposits occur on ocean floors, but some form on land and in fresh water. As time passes, the loose materials harden into solid rocks. Geologists divide these rocks into three groups, according to the type of material from which they are formed. These groups are (1) clastic sediments, (2) chemical sediments, and (3) organic sediments.

Clastic sediments are made from rock fragments that range in size from coarse boulders and cobbles, through pebbles and gravels, to fine grains of sand and particles of silt and clay. Rocks break and crumble into fragments by a natural process called weathering (see **Erosion** [How erosion occurs]). These fragments are carried about and deposited, chiefly by running water, but sometimes by wind and glaciers. Eventually, layers build up and then *lithification* (a stone-forming process) takes place. Sometimes pressure *compacts* (squeezes) the water from the deposits. This locks the particles together and forms rocks called *siltstone* from silt, and *shale* from clay. Natural chemical substances *cement* (bind) grains of sand together to form *sandstone.* Sometimes waterworn boulders, cobbles, and pebbles become cemented together to form *conglomerate* rocks. Broken and angular pieces become cemented to form *breccias.*

Chemical sediments are deposits of minerals that were once dissolved in water. The evaporation of the water causes minerals to crystallize, leaving deposits of *rock salt* (sodium chloride), *phosphate rocks* (calcium phosphate), and *gypsum* (calcium sulphate). Many *limestone* beds form from calcite (calcium carbonate) crystals, and some deposits of *iron ore* form from the crystallization of dissolved iron oxide. Dissolved silica makes beds of flint rocks.

Organic sediments are the shells, skeletons, and other parts of plants and animals. Shellfish take calcite from water and use it to build their shells. Coral polyps use the same mineral to build coral reefs (see **Coral**). Coral reefs and piles of shells harden to form *fossiliferous limestone.* The shells of one-celled organisms called *foraminifera* make *chalky limestone* such as that found in the famous white cliffs of Dover, England. Coal formed from ferns and other marsh plants that became buried in swamps and decayed. These deposits of organic matter hardened into beds of peat and coal (see **Coal** [How coal was formed]).

Common rocks

Rocks are classified into three major groups. *Igneous rock* forms from hardened magma. Hardening of various plant, animal, and mineral materials results in *sedimentary rock. Metamorphic rock* forms when any kind of rock undergoes changes as a result of intense heat and pressure.

Igneous

Basalt

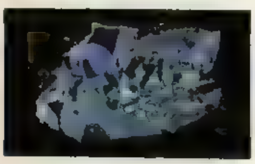
Gabbro

Granite

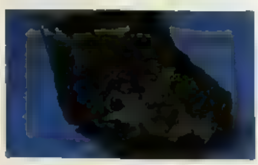
Obsidian

Sedimentary

Bituminous coal



Breccia

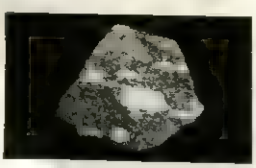


Flint

Limestone

Metamorphic

Amphibolite



Gneiss

Pink marble

Quartzite

Metamorphic rock

Metamorphic rock is rock that has changed its appearance, and in many cases, its mineral composition. These changes may be caused by hot magma or by pressure and heat due to deep burial or mountain-building movements in the earth's crust. All kinds of rock, including igneous and sedimentary, may go through such *metamorphism* to produce metamorphic rocks. Granite, for example, is an igneous rock that contains quartz, feldspar, and mica in a random arrangement. Metamorphism of granite causes feldspar and quartz crystals to form layers between which mica crystals often lie in wavy bands. The new rock is called *gneiss.* Metamorphism recrystallizes the calcite in limestone to form *marble.* The quartz grains in sandstone grow larger and form connecting crystals to create *quartzite.* Soft shales and clays harden to form *slate,* a rock that easily splits into smooth slabs. Felsites and impure sandstones, limestones, and shales change into *schists* that glisten with minerals such as chlorite, hornblende, and mica. Some minerals, including chlorite, garnet, and staurolite, occur only in metamorphic rocks.

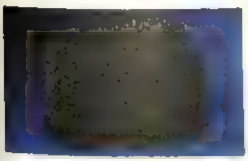
Rocks as a hobby

Collecting rocks. You can find interesting rocks and minerals in many places near your home. Good "hunting grounds" include mines, quarries, building excavations, ocean cliffs and beaches, and the rocky sides of road cuts and riverbanks. Be very careful when working near steep rock walls, and always obtain permission to visit private property. You can easily start a collection by gathering loose rocks, but a few simple tools will help in obtaining specimens.

The most important tool is a *rock hammer* that has a square head and a pointed end for pounding and loosening specimens embedded in solid rocks. A chisel helps loosen crystals. By examining rocks through a low-power magnifying glass you can choose the most desirable specimens. Many collectors carry a pocket magnet to help identify rocks containing magnetite. A *streak plate* (piece of unglazed porcelain) aids them in recognizing minerals by streak colours. A pocket knife makes a handy tool for testing mineral hardness. All this equipment can be bought inexpensively at a hardware store or from a mineral dealer. A small backpack makes a good carrying case. All rock specimens should be wrapped in newspaper or tissue paper for protection.

As you collect specimens, identify each with a label. The label should tell the location and date of collection, and what kind of rock or mineral it may be. Later you can transfer the information about the rocks and minerals to a permanent record book.

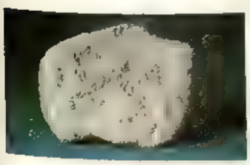
Identifying rocks may seem hard at first. But it soon becomes easy to recognize common types. Books with good colour pictures of rocks and minerals can be pur-


Peridotite


Pumice

Igneous rocks

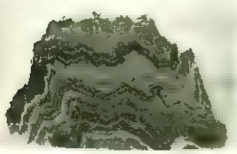
Rock	Colour	Structure
Basalt	Dark greenish-grey to black.	Dense, microscopic crystals, often form columns.
Gabbro	Greenish-grey to black.	Coarse crystals.
Granite	White to grey, pink to red.	Tightly arranged medium-to-coarse crystals.
Obsidian	Black, sometimes with brown streaks.	Glassy, no crystals, breaks with a shell-like fracture.
Peridotite	Greenish-grey.	Coarse crystals.
Pumice	Greyish-white.	Light, glassy, frothy, fine pores, floats on water.

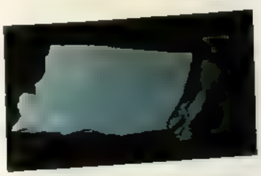

Sandstone


Shale

Sedimentary rocks

Rock	Colour	Structure
Breccia	Grey to black, tan to red.	Angular pieces of rock, held together by natural cement.
Coal	Shiny to dull black.	Brittle, in seams or layers.
Flint	Dark grey, black, brown.	Hard, glassy, breaks with a sharp edge.
Limestone	White, grey, and buff to black and red.	Dense, forms thick beds and cliffs. May contain fossils.
Sandstone	White, grey, yellow, red.	Fine or coarse grains cemented together in beds.
Shale	Yellow, red, grey, green, black.	Dense, fine particles, soft, splits easily, smells like clay.


Schist


Slate

Metamorphic rocks

Rock	Colour	Structure
Amphibolite	Light green to black.	Fine-to-coarse grains, hard, often sparkles.
Gneiss	Grey and pink to black and red.	Medium to coarse crystals arranged in bands.
Marble	Many colours, often mixed.	Medium to coarse crystals, may be banded.
Quartzite	White, grey, pink, buff.	Massive, hard, often glassy.
Schist	White, grey, red, green, black.	Flaky particles, finely banded, feels slippery, often sparkles with mica.
Slate	Black, red, green, purple.	Fine grains, dense, splits into thin, smooth slabs.

chased. Many beginners buy inexpensive *reference collections* of rocks or minerals from rock and mineral dealers. These collections identify common rocks and minerals. You can compare unknown rocks with pictures and with known specimens.

All minerals have characteristics, such as chemical composition, hardness, and streak colour, that help identify them. Experienced collectors also study the formations in which rocks are found, and the physical characteristics of the rocks.

Chemical composition may be determined by certain chemical tests for the mineral elements. For example, a simple chemical test for calcite in limestone is to pour warm lemonade over the rock. The lemonade, a weak acid, fizzes vigorously on limestone.

Hardness is a measure of how easy it is to scratch a mineral. Soft minerals can be scratched with your fingernail. Harder minerals are scratched by a steel knife blade or pin, and the hardest resist scratching by all materials except diamond—the hardest mineral known.

Streak colour is the colour of the powder obtained by rubbing a mineral across a hard, rough surface such as unglazed porcelain or a file. The powder colour often differs from the colour of the mineral mass. For example, pyrite (ferrous sulphide) looks yellow in rocks. But its streak colour is black. Many minerals have a typical streak colour.

Formations and physical characteristics. You can often identify rocks by knowing where they are found and how they look. For example, you usually can recognize sedimentary rocks because they lie in *stratified,* or layered, formations. Sedimentary rocks often contain fossils, and many have markings such as old mud cracks or ripple marks caused by waves. Geologists often use fossils to find out when the rock has been formed. Often they find fossils by carefully splitting sedimentary rocks with a hammer. Except for volcanic glass, all igneous rocks are solid and crystalline. Some appear dense, with microscopic crystals, and others have larger, easily seen crystals. They occur in volcanic areas, and in intrusive formations that geologists call batholiths, laccoliths, sills, dikes, and stocks. Many metamorphic rocks have characteristic bands, and can be split easily into sheets or slabs. See also Mineral (Identifying minerals).

Displaying rocks. The size of the rocks in your collection will depend on the available storage space.

Collecting rocks is fun and challenging. This boy is using a magnifying glass and reference books to identify a specimen.

Some people collect small *micromounts,* that can be kept in small boxes and viewed under a low-power microscope. Others prefer larger specimens of the size found in museum collections. Probably the best size for storage ranges from 5 by 8 centimetres to about 8 by 10 centimetres. Crystals, of course, would be smaller. You can trim rocks to the desired size by using your hammer, but be careful not to damage choice crystals. Dirty specimens can be cleaned by washing with soap and water, and brushing with a stiff brush. Specimens containing rock salt cannot be washed, because the salt dissolves in water. Usually, you can brush or blow the dirt from such specimens.

After cleaning your specimens, you can catalogue them by painting a small white spot on each rock and writing a number on the spot with waterproof ink. This allows you to refer to the corresponding number in your record book for information about each one.

A chest of drawers or a set of bookshelves makes an ideal storage unit. Put your rocks in shallow cardboard trays. You might keep very small specimens and crystals in cardboard boxes or trays that have partitions. Small exhibits of choice specimens make attractive displays on mantels or shelves, or in glass-front cases.

Rock collections. Many public museums in larger cities exhibit excellent collections of rocks and minerals.

Interesting facts about rocks

Balanced Rock, in the Garden of the Gods near Colorado Springs, Colorado, U.S.A., is an enormous block of sandstone delicately balanced on a small base.

Bendable rock. Most rocks cannot be bent or squeezed out of shape. But thin slabs of itacolumite, a rare kind of sandstone found in India and North Carolina, U.S.A., can be bent by hand because of their crystalline structure.

Eight elements make up more than 98 per cent of all the rocks in the world. These elements are found in about the following percentages: oxygen (46.5), silicon (27.6), aluminium (8.0), iron (5.0), calcium (3.6), sodium (2.8), potassium (2.6), and magnesium (2.0).

Floating rock. Pumice is a rock that floats on water. It was once volcanic lava filled with gases. When the gases escaped, they left millions of tiny holes that filled with air.

Rock of Gibraltar is a huge block of limestone near the southern tip of the mainland of Europe.

Related articles in *World Book* include:

Famous rock formations

Giant's Causeway	Gibraltar

Igneous rocks

Basalt	Obsidian
Granite	Pumice
Lava	

Metamorphic rocks

Gneiss	Quartzite	Soapstone
Marble	Slate	

Sedimentary rocks

Chalk	Coral	Sandstone
Clay	Flint	Shale
Coal	Limestone	Travertine

Other related articles

Building stone	Gem	Mining	Pyroxene
Cliff	Geode	Moon (What the moon is made of; pictures)	Quarrying
Corrosion	Geology		Sand
Crystal	Gravel		Soil
Earth	Hardness		Taconite
Emery	Loess	Mountain	Tektite
Erosion	Metamorphism	Ore	Volcano
Fossil		Petrology	

Rock crystal. See Quartz.

Rock festival. See Rock music (Expanding styles and sounds).

Rock music is one of the world's most popular and adaptable musical forms. When it originated in the United States in the early 1950's, rock music was known as *rock 'n' roll* (also spelled *rock and roll*). From the start, it was party music, dance music, and music that appealed to young listeners. It often celebrated the joys of being young, and it occasionally expressed the frustrations of youth. It rapidly spread and became an international expression of youth culture.

Many adults dismissed rock 'n' roll as a passing fad or condemned it as a threat to society. By the mid-1960's, however, rock 'n' roll had earned wide respect as a legitimate art form. By the end of the 1960's, the music had moved far from its roots in blues and country music, and it became known simply as *rock.*

Since then, rock has not only dominated the music industry, but has also influenced everything from film to fashion to politics. Rock music has continued to defy musical barriers and has drawn much of its strength from international musical influences.

Characteristics of rock music

At first, rock music generally followed a $\frac{4}{4}$ beat and used only two or three chords in its melody. The songs were simple, repetitive, and easy to remember. Most of them were only two or three minutes long. The simplest rock continues to rely on a basic beat and a few chords. But some rock songs are more complex and sophisticated. Traditional musical elements from Africa, Ireland, South America, and other places have become more widely used in rock music.

Many rock groups feature a vocal soloist, with other group members performing as a chorus. Early rock music featured electric guitar or a blues-style boogie-woogie piano and drums. Today, musicians may use computers and electronic instruments called *synthesizers* as well as guitars, pianos, and drums. Some recordings include electronic drum machines. Many studio recordings rely heavily on computer technology.

Beginnings of rock music

Musical roots. Rock developed from a variety of different popular music styles. The roots of rock can be heard in the lyrics and electric guitar of the blues, in the rhythms of a form of blues known as *rhythm and blues,* and in the spirit of American country music. The squawking saxophone of dance-band jazz, and the melodies, choruses, and harmonies of popular (pop) music also added to the rock sound.

Many of the elements of rock music had been around long before rock developed as a musical form. In the 1950's, musicians combined these musical elements and

Elvis Presley, *centre,* became rock's first superstar. His tough, rebellious manner and suggestive movements are apparent in this scene from the film *Jailhouse Rock* (1957).

created the revolutionary form of music called rock 'n' roll. It was louder and faster than the forms from which it drew. Its lyrics contrasted sharply with the sentimental lyrics of earlier pop songs. And it was generally performed in a wild and spontaneous manner with a more primitive and raw display of emotions.

The emergence of rock 'n' roll. Before rock 'n' roll became a musical category, such rhythm and blues hits as "Rocket '88" (1951) by Jackie Brenston had the spirit of rock 'n' roll. This and other similar records became increasingly popular with both black rhythm and blues audiences and white country music audiences.

The major rock 'n' roll explosion began with Elvis Presley. The popularity of his sound combined with his hip-shaking live performances and frequent radio play quickly made Presley a superstar. His first major success came with his 1956 recording of "Heartbreak Hotel" for RCA Victor.

Another important influence on rock music was St. Louis blues artist Chuck Berry. He was the first of the great rock songwriters. His lyrics effectively expressed the feelings and problems of youth. Berry's first hit record was a country-styled tune titled "Maybellene" (1955).

Richard Penniman, known as Little Richard, helped influence rock performance styles. His vigorous and flamboyant stage performances provided a model for performers who followed. His first major success came in 1955 with "Tutti Frutti."

Bill Haley and the Comets became the first famous rock band. Their recording of "Rock Around the Clock" was the first international rock hit. It was used as the theme song for *The Blackboard Jungle,* a 1955 film about juvenile delinquents. The song contributed to rock 'n' roll's reputation as music of rebellion.

Growing popularity. Radio played an important role in spreading rock music during the mid-1950's. Television had replaced radio as the chief producer of drama

Chuck Berry helped define the spirit of rock 'n' roll in the 1950's. His rocking guitar rhythms and vivid lyrics effectively expressed the feelings and problems of youth.

and variety entertainment, and many radio stations began to play rock to capture an audience.

Though the United States was racially divided, rock 'n' roll featured black and white artists, who appealed to black and white audiences alike. Most important for its young listeners, rock 'n' roll was the first music that was all their own. Rock 'n' roll proclaimed that being a teenager was special. Although rock 'n' roll was extremely popular, its lyrics and the performance style that went with it were still considered indecent by many adults.

Artistic decline. As rock 'n' roll continued to grow in popularity, the major record companies and professional songwriters who had ignored the music started to recognize rock 'n' roll's profitability. By the late 1950's, much of what record companies released as rock 'n' roll was no longer wild, spontaneous, and rebellious. The music was much tamer than it had been.

Rock 'n' roll also lost many of its stars and creative forces toward the end of the 1950's. In 1958, Elvis Presley was drafted into the United States Army and rocking pianist Jerry Lee Lewis caused a scandal by marrying his 13-year-old cousin. Then in 1959, Chuck Berry was arrested. In the same year, songwriter-guitarist Buddy Holly and singer-guitarist Ritchie Valens died in an aeroplane crash, and Little Richard left music to study for the ministry.

British influence and rock's revival

The Beatles. The Beatles, a group from Liverpool, England, returned excitement to rock 'n' roll in the early 1960's. They made the music more popular than ever and more respected artistically. Their witty and sophisticated music made the sentimental rock of the time seem tame and old-fashioned.

The Beatles consisted of George Harrison, John Lennon, Paul McCartney, and Ringo Starr. Their first hit was "Love Me Do" in 1962. Lennon and McCartney eventually established themselves as the most popular songwriting team in rock's history.

Beatlemania was the term generally used to describe the excitement generated by the Beatles. It affected society in a number of ways. Teenage boys began growing their hair longer to copy the Beatles. Teenage girls screamed so loudly during the band's concerts that it was impossible to hear the music. At first, many parents feared the effects of Beatlemania. But the personal charm and musical appeal of the band soon conquered older listeners.

The Beatles turned rock 'n' roll from an American-dominated musical style into an international phenomenon. Soon after the Beatles hit the United States, popular music charts became filled with songs by British bands that wrote and played their own music.

The Rolling Stones were another of the groups that contributed to the British domination of rock music. They represented a scruffier, more rebellious alternative to the more widely accepted Beatles. Their music also was more faithful to its roots in the blues. Other British bands that became popular included The Who, the Kinks, and the Animals.

Expanding styles and sounds. Another major force in the rock of the 1960's was the American singer-songwriter Bob Dylan. The strong social message of Dylan's songs influenced many musicians.

The Beatles, shown here at a 1965 press conference, earned a huge international following with their witty, sophisticated songs and whimsical humour. Their sensational popularity—called *Beatlemania*—resulted in mobbing fans, Beatle fashions, and tremendous media coverage of the band.

Rock music's energetic style is captured by Mick Jagger, *right,* and Ron Wood, *left,* of the Rolling Stones. Formed in 1962, the "Stones" have been one of rock's most enduring groups.

Dylan began his musical career in the early 1960's as a solo folk singer. Music fans turned to Dylan for his "protest songs." These songs protested about what many people considered the wrongs of society, such as racial prejudice, poverty, and war. Dylan's protest songs include "Blowin' in the Wind" (1962) and "A Hard Rain's A-Gonna Fall" (1963).

Dylan had his first and biggest rock hit in 1965 with "Like a Rolling Stone." An American group, the Byrds, also interpreted Dylan's ambitious, poetic lyrics set to a rock beat. This style became known as *folk rock.*

The mid-1960's became a time of peak creativity for rock music. Rock artists explored new possibilities in lyrical content and form. Some began to examine the meaning of dreams in their lyrics. One such artist was Jim Morrison, lead singer of the Doors. Songwriters began to use *free-verse* poetry that did not rhyme. Some musicians also began to produce *concept albums,* which linked their songs together by story line or theme. One such album was *Sgt. Pepper's Lonely Hearts Club Band* (1967) by the Beatles.

The 1960's also found instrumentalists exercising more creative freedom. American guitarist Jimi Hendrix, working in England, extended the range of the electric guitar by using electronic effects to create new sounds. In addition, such instrumentalists as Hendrix and British guitarist Eric Clapton played extended solos inspired by blues and jazz traditions. The music played by such bands as the Jimi Hendrix Experience and Clapton's Cream was sometimes categorized as *progressive rock.* Some of their music was also called *acid rock,* after the illegal drug LSD, or "acid," which was popular among some rock fans.

Growing social significance. The growing influence and popularity of rock music affected society in a number of ways. It produced new fashions, such as Beatle boots and longer hairstyles. Some rock music inspired public protest against such social and political problems as racial prejudice and the Vietnam War.

Toward the end of the 1960's, rock's various styles came together at massive outdoor rock festivals. These festivals showed how popular and diverse the music had become. The most significant rock festival was the 1969 Woodstock Music and Arts Festival in New York State. Woodstock was a musical, communal celebration of the alternative "hippie" culture. It was dedicated to world peace. The event drew more than 300,000 fans and featured three days of top rock talent. It included such performers as the Grateful Dead, Jimi Hendrix, Jefferson Airplane, and blues singer Janis Joplin.

Rock music in the 1970's

Rock goes pop. Throughout the 1970's, almost all popular music contained elements of the rock style. The music's audience spanned from preteens to middle-aged adults. As the audience for rock grew, a variety of new musical categories developed. Musicians such as Chick Corea and such groups as Chicago and Weather Report blended rock with the improvisation techniques of jazz to create a form called *jazz rock. Heavy metal rock* groups, such as Led Zeppelin, AC/DC, and Kiss, stressed screaming electric guitars. The *glitter rock* of David Bowie and others popularized flamboyant on-stage visuals. Musician Frank Zappa and groups including King Crimson and Emerson, Lake, and Palmer combined a rock beat with the more complex melodies of classical music in a form called *art rock.*

In terms of musical quality, the early 1970's were generally considered rock's lowest point since the pre-Beatles 1960's. Through its attempt to appeal to a wide audience, rock lost much of the youthful energy and spirit of rebellion that had once powered it.

By the mid-1970's, the music started to reclaim some of the inspiration and energy associated with earlier rock. Bruce Springsteen and the E Street Band attracted an enthusiastic following with "Born to Run" (1975). Springsteen's music reflected the energetic rock 'n' roll and rhythm and blues music of the 1950's. He showed how rock might find a future by drawing from its past.

Punk. With the *punk rock* of the mid-1970's, such British bands as the Sex Pistols and the Clash returned to the raw energy of earlier rock. They were fuelled by an anger at the materialism of society and the lack of inspiration in much of the early 1970's rock music. Punk had a number of important effects on rock music. It proved that new styles could develop outside the established rock industry. Rather than working for the large record empires, they recorded their music with small, independent companies.

Such New York City bands as Talking Heads and the Patti Smith Group took an artier approach to punk rock. These groups became categorized as punk's *new wave* of rock. The music of punk and new wave bands represented an aggressive alternative to the more established musicians who dominated the rock industry.

At first, disco music and punk were considered opposites. But they came together in the late 1970's. Blondie and other groups enjoyed hits that combined disco rhythms with the spirit of new wave rock.

Rock music in the 1980's and 1990's

New directions and old. The most popular new music to emerge from the 1980's was *rap music.* Rap is

Rock musicians have worked to promote social change around the world. This photo shows, *from left to right,* the musicians Peter Gabriel, Tracy Chapman, Youssou N'Dour, Sting, Joan Baez, and Bruce Springsteen at an Amnesty International concert designed to help raise awareness of human rights issues.

spoken rather than sung. Electronic rhythms and sounds of records being *scratched* (the record is physically pushed backward and forward to create a percussive effect) provide background music. Rap's streetwise rhymes and chants reflect the concerns of urban youths living in a tough world. Public Enemy became one of the most successful rap groups.

Music from the 1960's inspired some of rock's most popular musicians of the 1980's. Among these musicians was the American band R.E.M., which drew heavily from 1960's folk rock. In addition, some bands from the 1960's, such as the Rolling Stones, Pink Floyd, and the Grateful Dead, were among the leading concert attractions of the 1980's.

Rock videos. During the 1980's, *rock videos* became popular. They are short films made to accompany the release of new records. In addition to music, these films include acting, dancing, striking visual images, and sometimes excerpts from rock concert performances. Rock videos were shown on commercial and cable television and at many dance clubs. The rise of rock videos brought widespread exposure and massive popularity to a number of artists. Many songs became as popular for the visual element of the video as they did for the music.

Madonna, one of rock's superstars of the 1980's and 1990's, gained fame for her recordings, videos, and live performances.

The American singer and dancer Michael Jackson starred in several highly successful videos and became one of the most popular performers in the history of rock music. His *Thriller* (1982) became the largest-selling record album of all time.

Technological changes. Since 1980, rock has continued to reflect an ongoing technological revolution. Computers, synthesizers, and rhythm machines have often replaced guitars and drums. Even in concert, musicians have mixed live music with preprogrammed computer and synthesizer backing.

Rock and internationalism. During the 1980's, rock displayed a broadening interest in international concerns and a reawakening of its social idealism. Several artists, including Peter Gabriel, Talking Heads, and Paul Simon, incorporated the music of Africa into their music.

Rock's idealism and internationalism came together in such events as Live Aid, an all-day concert held in July 1985. Money raised by the event went to help feed starving people in Africa. The concert, held in both Philadelphia and London, was televised throughout the world and featured many of the biggest stars in rock. In the early 1990's, rock musicians continued to explore international music as a source of inspiration.

Related articles in *World Book* include:

Beatles
Berry, Chuck
Blues
Country music
Dylan, Bob
Electronic music
Hendrix, Jimi
Holly, Buddy
Jackson, Michael
Jazz (Fusion)
Lennon, John
McCartney, Paul
Popular music
Presley, Elvis
Radio (Broadcasting today)
Reggae
Rolling Stones
Simon, Paul
Springsteen, Bruce
Synthesizer
Who, The
Wonder, Stevie

Rock oil. See Petroleum.

Rockall is a small island in the North Atlantic. It lies about 360 kilometres due west of the island of North Uist in the Outer Hebrides, Scotland. Rockall is about 420 kilometres northwest of Londonderry, in Northern Ireland. The islet is completely isolated. Rockall is composed of granite and rises about 20 metres out of the sea. It measures about 90 metres in circumference. The United Kingdom annexed the island of Rockall in 1955.

Rockefeller is one of the most famous names in American business, finance, and *philanthropy* (charity). Three members of the family also became active in politics. One of them, Nelson A. Rockefeller, served as governor of New York from 1959 to 1973 and was vice president of the United States from 1974 to 1977.

John Davison Rockefeller (1839-1937), an American businessman, was once the world's richest person. He made his fortune in the oil business and later became famous for his philanthropy.

Many people have criticized the business methods that Rockefeller used in developing his vast industrial empire. But his contributions to the welfare of humanity form an equally important part of his record.

Rockefeller was born in Richford, near Ithaca, New York. He entered the oil business at the age of 23.

The Standard Oil Company, which was established in 1870, grew out of several oil companies owned by Rockefeller, his younger brother William, and some associates. By the end of the 1870's, it owned the main refineries in Cleveland, New York City, Pittsburgh, and Philadelphia.

In 1882, Rockefeller organized the Standard Oil Trust. He then controlled almost all United States oil refining and distribution and much of the world's oil trade.

The vastness of Rockefeller's holdings—plus public criticism of his methods—caused the Ohio Supreme Court to dissolve the Standard Oil Trust in 1892. The Standard Oil Company of New Jersey, a holding company, replaced the trust. In 1911, the Supreme Court of the United States ordered the firm to dissolve. See **Antitrust laws; Standard Oil Company; Holding company.**

From 1895 to 1897, Rockefeller gradually retired from active business. By that time, he had started his philanthropic activities. For example, he helped found the University of Chicago in 1890. By 1910, his gifts to that institution totalled 35 million U.S. dollars. Rockefeller spent the rest of his life establishing the foundations through which he gave his money to the public.

John Davison Rockefeller, Jr. (1874-1960), was the only son of John D. Rockefeller. He became a business associate of his father after graduating from Brown University. He devoted most of his life to extending the philanthropic work started by his father. Rockefeller donated $8\frac{1}{2}$ million U.S. dollars to buy land for United Nations headquarters in New York City. He also built Rockefeller Center, a landmark of New York City.

John Davison Rockefeller III (1906-1978) was the oldest son of John D. Rockefeller, Jr. He served as chairman of the board of trustees of the Rockefeller Foundation from 1952 to 1971. Rockefeller helped found the Lincoln Center for the Performing Arts in New York City and later became its chairman. He also founded the Population Council, a group that conducts research on population problems throughout the world. Rockefeller served as chairman of the President's Commission on Population Growth and the American Future.

Rockefeller was born in New York City. He graduated from Princeton University.

Nelson Aldrich Rockefeller (1908-1979), son of John D. Rockefeller, Jr., served as vice president of the United States from 1974 to 1977. He took up the position when Vice President Gerald Ford succeeded Richard Nixon, who had resigned as president. Rockefeller, a Republican, had served as governor of New York from 1959 to 1973.

Rockefeller was born in Bar Harbor, Maine. In 1944 and 1945, Rockefeller served as assistant secretary of state. He was undersecretary of health, education, and welfare in 1953 and 1954, and special assistant to President Dwight D. Eisenhower in 1954 and 1955.

John Davison Rockefeller IV (1937-   ), son of John D. Rockefeller III, was elected a United States senator from West Virginia in 1984. Rockefeller, a Democrat, served as West Virginia's governor from 1977 until 1985. He was secretary of state of West Virginia from 1969 to 1973. Rockefeller served as president of West Virginia Wesleyan College from 1973 to 1975.

Rockefeller was born in New York City. He was a member of the West Virginia House of Delegates from 1967 to 1969.

John D. Rockefeller, *left,* became famous for his philanthropies. In his later years, Rockefeller often gave shiny new coins as mementos to strangers he met. At his death, his heirs included, *left to right,* his son, John D., Jr., and his grandsons David, Nelson, Winthrop, Laurance, and John D. III.

The giant Saturn V rocket that carried the first astronauts to the moon rises from its launch tower. Rockets are the only vehicles used for launching people and machines into space.

Rocket

Rocket is a type of engine that can produce more power for its size than any other kind of engine. A rocket can produce about 3,000 times more power than a car engine of the same size. The word *rocket* can also be used to describe the vehicle driven by a rocket engine.

Rockets are made in many sizes. Some of the rockets used to shoot fireworks into the sky are only 60 centimetres long. Rockets 15 to 30 metres long carry giant missiles to bomb distant enemy targets. Larger and more powerful rockets are generally required to lift artificial satellites into orbit around the earth. The Saturn V rocket that carried astronauts to the moon stood more than 110 metres high.

A rocket can produce great power, but it burns fuel rapidly. For this reason, a rocket must have a large amount of fuel to work for even a short time. The Saturn V rocket burned over 2,120,000 litres of fuel during the first $2\frac{3}{4}$ minutes of flight. Rockets become very hot as they burn fuel. The temperature in some rocket engines reaches 3300° C, about twice the temperature at which steel melts.

Rocket technology developed mainly after World War II (1939-1945). It is a very complex technology because rocket engines must withstand not only very high temperatures but also extremely high pressures and strong mechanical forces, and yet still be light enough to fulfil their task. People use rockets chiefly for scientific research, space travel, and war.

Rockets have been used in war for hundreds of years. In the 1200's, Chinese soldiers fired them against attacking armies. British troops used rockets to attack Fort McHenry in Maryland, U.S.A. during the War of 1812 (1812-1814). After watching the battle, Francis Scott Key described "the rockets' red glare" in his words for the U.S. national anthem, "The Star-Spangled Banner." During World War I (1914-1918), the French used rockets to shoot down enemy aeroplanes. Germany attacked London with rockets during World War II. Today's rockets can destroy satellites in orbit around the earth, as well as jet aeroplanes and missiles that fly faster than the speed of sound.

Scientists use rockets for exploration and research in the atmosphere and in space. Rockets carry scientific instruments high in the sky to gather information about the air that surrounds the earth. Since 1957, rockets have shot hundreds of satellites into orbit around the earth. These satellites perform many tasks including acting as communications links, taking pictures of the earth's weather, and gathering other information for scientific study. Rockets also carry instruments far into space to explore the moon, the planets, and even the space among the planets.

Rockets provide power for human space flights, which began in 1961. In 1969, rockets carried astronauts to the first landing on the moon. In 1981, rocket power launched the first space shuttle into orbit around the earth. In the future, rockets may carry people to Mars and the other planets.

How rockets work

A basic law of motion—discovered in the 1600's by the English scientist Sir Isaac Newton—describes how rockets work. This law states that for every action, there is an equal and opposite reaction (see **Motion** [Newton's laws of motion]). Newton's law explains why the flow of air from a toy balloon *propels* (drives forward) the balloon in flight. A powerful rocket works in much the same way.

A rocket burns special fuel in a *combustion* (burning) chamber and creates rapidly expanding gas. This gas presses out equally in all directions inside the rocket. The pressure of the gas against one side of the rocket balances the pressure of the gas against the opposite side. The gas flowing to the rear of the rocket escapes through a nozzle. This exhaust gas does not balance the pressure of gas against the front of the rocket. The uneven pressure drives the rocket forward.

The flow of gas through the nozzle of a rocket is the *action* described in Newton's law. The *reaction* is the continuous *thrust* (pushing force) of the rocket away from the flow of exhaust gas.

Rocket propellant. Rockets burn a combination of chemicals called *propellant.* Rocket propellant consists of (1) a fuel, such as petrol, paraffin, or liquid hydrogen; and (2) *an oxidizer* (a substance that supplies oxygen), such as nitrogen tetroxide or liquid oxygen. The oxidizer supplies the oxygen that the fuel needs to burn. This supply of oxygen enables the rocket to work in space, which has no air.

Jet engines also work by means of an action-reaction process. But jet fuel does not contain an oxidizer. Jet engines draw oxygen from the air and, for this reason, cannot function outside of the earth's atmosphere. See **Jet propulsion.**

A rocket burns propellant rapidly, and most rockets carry a supply that lasts only a few minutes. But a rocket produces such great thrust that it can hurl heavy vehicles far into space.

A rocket burns the most propellant during the first few minutes of flight. During that time, the rocket's speed is held down by air friction, gravity, and the weight of the propellant. Air friction drags on the rocket as long as the rocket travels through the atmosphere. As the rocket climbs higher, the air becomes thinner and the friction decreases. In space, no air friction acts on the rocket. Gravity pulls a rocket toward the earth, but the pull decreases as the rocket travels farther from the earth. As a rocket burns its propellant, the weight it must carry becomes less.

Multistage rockets consist of two or more sections called *stages.* Each stage has a rocket engine and propellant. Engineers developed multistage rockets for long flights through the atmosphere and for flights into space. They needed rockets that could reach greater speeds than were possible with single-stage rockets. A multistage rocket can reach higher speeds because it lightens its weight by dropping stages as it uses up propellant. A three-stage rocket can reach about three times the speed of a single-stage rocket.

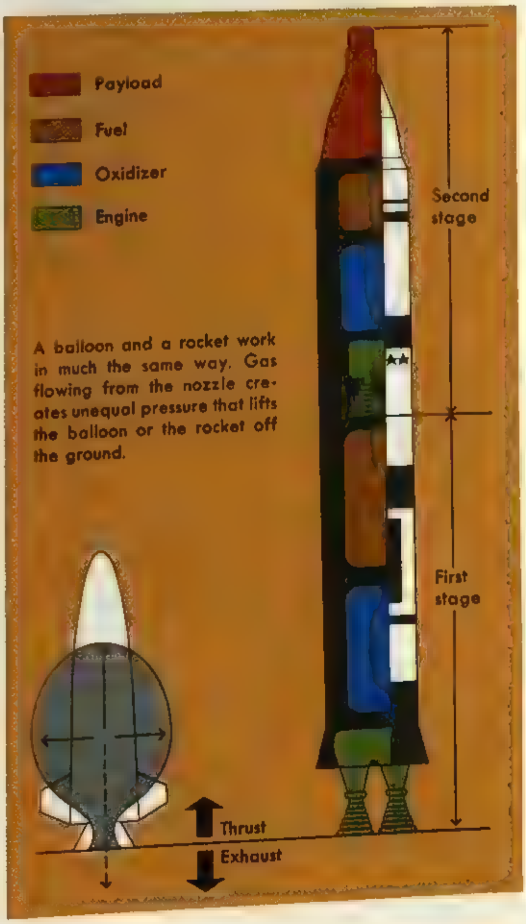
The first stage, called the *booster,* launches the rocket. After the first stage has burned its propellant, the vehicle drops that section and uses the second stage. The rocket continues using one stage after another. Most space rockets have two or three stages.

Launching a rocket. Space rockets require specially equipped launch sites. All launching activity at a site centres around the launch pad, from which the rocket is fired. A launch site also has (1) assembly buildings, where engineers complete the final steps of rocket construction; (2) service structures, where workers check the rocket before launching; and (3) a control centre, where scientists direct the launch and flight of the rocket. Tracking stations, located around the world, record the path of the rocket's flight.

Engineers prepare a rocket for launching in a step-by-step process called the *countdown.* They schedule each step for a specific time during the countdown and launch the rocket when the countdown reaches "zero." Undesirable weather or some other difficulty may cause a *hold,* which temporarily stops the countdown.

How a multistage rocket works

A two-stage rocket carries a propellant and one or more rocket engines in each stage. The first stage launches the rocket. After burning its supply of propellant, the first stage falls away from the rest of the rocket. The second stage then ignites and carries the payload into earth orbit or even farther into space.



How rockets are used

People use rockets chiefly to provide high-speed transportation, both within the earth's atmosphere and in space. Rockets are especially valuable for (1) military use, (2) atmospheric research, (3) launching probes and satellites, and (4) space travel.

Military use. Rockets used by the military vary in size from small, battlefield rockets to giant guided missiles that can fly across an ocean.

The *bazooka* is a small rocket launcher carried by soldiers for use against armoured vehicles. A person using a bazooka has as much striking power as a small tank (see **Bazooka**). Armies use larger rockets to fire explosives far behind enemy lines and to shoot down enemy aircraft. Fighter aeroplanes carry guided missiles to attack other planes and ground targets. Navy ships use guided missiles to attack other ships, land targets, and planes.

One of the most important military uses of rockets is to propel a type of long-range guided missile called an *intercontinental ballistic missile* (ICBM). Such a missile can travel more than 8,000 kilometres to bomb an enemy target with nuclear explosives. A set of powerful rockets launches an ICBM and propels it during the early part of its flight. The ICBM coasts the rest of the way to its target. See **Guided missile.**

Atmospheric research. Scientists use rockets to explore the earth's atmosphere. *Sounding rockets,* also called *meteorological rockets,* carry such equipment as barometers, cameras, and thermometers high into the atmosphere. These instruments collect information about the atmosphere and send it by radio to receiving equipment on the earth. This method of collecting information and sending it great distances by radio is called *telemetry* (see **Telemetry**).

Rockets also provide the power for experimental research aeroplanes. Engineers use these planes in the development of spacecraft. By studying the flights of such planes as the rocket-powered X-15, engineers learn how to control vehicles flying many times faster than the speed of sound.

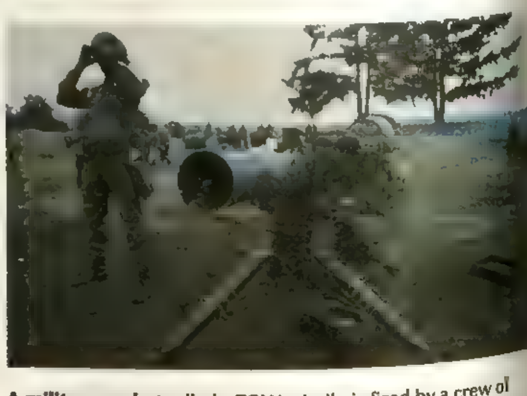
Launching probes and satellites. Rockets that carry research equipment on long voyages to explore the solar system are called *probes. Lunar probes* gather information about the moon. They may fly past the moon, orbit it, or land on its surface. *Interplanetary probes* take one-way journeys into the space among the planets. *Planetary probes* collect information about the planets. A planetary probe travels in orbit around the sun with the planet it is exploring. The first planetary probes explored Mars and Venus. Probes have also explored Jupiter, Saturn, Neptune, and Venus.

Rockets lift artificial satellites into orbit around the earth. Some orbiting satellites gather information for scientific research. Others relay telephone conversations and radio and television broadcasts across the oceans (see **Satellite, Artificial**). The armed forces use satellites for communications and to guard against surprise missile attack. They also use satellites to photograph enemy missile sites.

Rockets that launch probes and satellites are called *carrier rockets* or *launch vehicles.* Most of these rockets have from two to four stages. The stages lift a satellite to its proper altitude and give it enough speed—about 29,000 kilometres per hour—to stay in orbit. An interplanetary probe's speed must reach about 40,200 kilometres per hour to escape earth's gravity and continue on its voyage.

Space travel. Rockets provide the power for spacecraft that orbit the earth and travel to the moon and the planets. These rockets, like the ones used to launch probes and satellites, are called carrier rockets or launch vehicles.

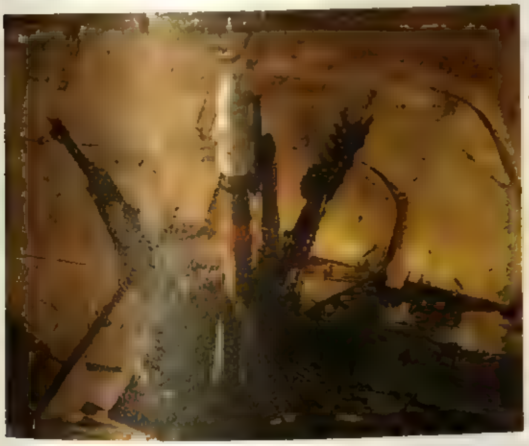
Sounding rockets, such as this Taurus-Nike-Tomahawk, collect information about the earth's upper atmosphere. Radio equipment in the rocket sends data to the earth for scientific study.



A military rocket called a TOW missile is fired by a crew of two. TOW stands for *T*ube-launched, *O*ptically tracked, *W*ire-guided missile. It can be fired from the ground or a vehicle.

The first space launch vehicles were military rockets or sounding rockets that engineers changed slightly to carry spacecraft. For example, they added stages to some of these rockets to increase their power. Today, engineers sometimes attach smaller rockets to the first stage of a launch vehicle. These *piggyback boosters* provide additional thrust to launch heavier spacecraft.

The Saturn V rocket, which carried United States astronauts to the moon, was the most powerful U.S. launch vehicle. Before launch, it weighed more than 2.7 million kilograms and stood about 111 metres tall. It could send a spacecraft weighing more than 45,000 kilograms to the moon. The Saturn V used 11 rocket engines to propel three stages.



A Soviet rocket sits on its pad before launching the Soyuz 6 spacecraft in 1969. Soyuz 6 was the first of three manned spacecraft launched in three days by the Soviet Union.

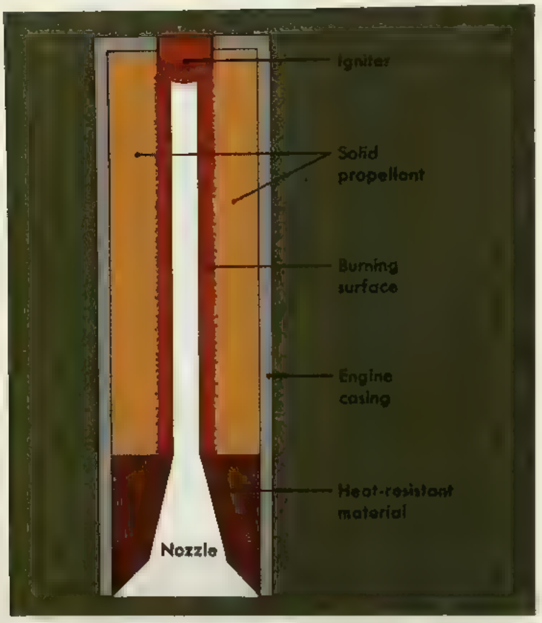
An Orbiting Astronomical Observatory satellite is prepared by technicians for launch. Such satellites gather information about stars and galaxies that are deep in space.

Reusable space shuttles, which are used to launch satellites, can fly into space and return to the earth for repeated journeys. In the future, space shuttles may carry people and supplies to and from space stations that will orbit the earth. Also, smaller rocket-powered vehicles called *space tugs* one day may provide transportation over short distances, such as from a shuttle vehicle to a space station or from one satellite to another. Such vehicles may also provide power for space probes launched to the planets from earth orbit. See **Space travel**.

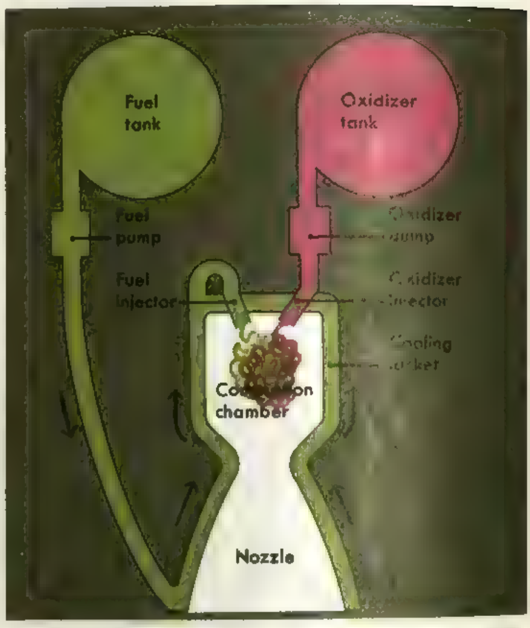
Other uses. Rockets have been used for many years as distress signals from ships and aeroplanes and from the ground. Rockets also shoot rescue lines to ships in distress. Small rockets called *JATO* (*j*et-*a*ssisted *t*ake-*o*ff) *units* help heavily loaded aeroplanes take off. Rockets have long been used in fireworks displays (see **Fireworks**). Scientists even use rockets to "seed" clouds with chemicals in an effort to control the weather (see **Weather** [Attempts to control the weather]).

An Atlas-Centaur rocket lights up its launch pad during liftoff. These rockets place such scientific satellites as those of the Orbiting Astronomical Observatory in orbit around the earth.

Kinds of rocket engines



A solid-propellant rocket burns a solid material called the *grain*. Engineers design most grains with a hollow core. The propellant burns from the core outward. Unburned propellant shields the engine casing from the heat of combustion.



A liquid-propellant rocket carries fuel and an oxidizer in separate tanks. The fuel circulates through the engine's cooling jacket before entering the combustion chamber. This circulation preheats the fuel for combustion and helps cool the rocket.

There are four basic kinds of rockets: (1) solid-propellant rockets, (2) liquid-propellant rockets, (3) electric rockets, and (4) nuclear rockets.

Solid-propellant rockets burn a rubbery or plastic-like material called the *grain*. The grain consists of a fuel and an oxidizer in solid form. Unlike some liquid propellants, the fuel and oxidizer of a solid propellant do not burn upon contact with each other. The propellant must be ignited in one of two ways. It may be ignited by the burning of a small charge of *black powder*, a mixture of saltpetre, charcoal, and sulphur. The propellant also may be ignited by the chemical reaction of a liquid chlorine compound sprayed onto the grain.

The temperature in the combustion chamber of a solid-propellant rocket ranges from 1600° to 3300° C. In most of these rockets, engineers use high-strength steel or titanium to build chamber walls that can stand the pressure created at such high temperatures. They also may use fibreglass or special plastic materials.

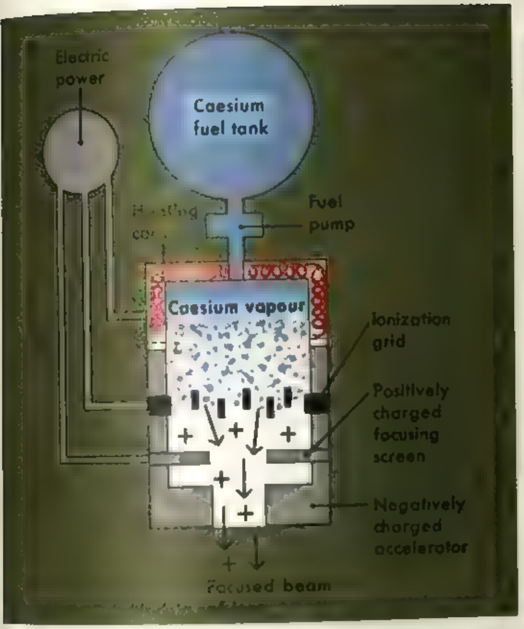
Solid propellants burn faster than do liquid propellants. But they usually produce less thrust than an equal amount of liquid propellant burned in the same time. Solid propellants remain effective for long periods of storage and present little danger of exploding until ignited. They do not require the pumping and blending equipment needed for liquid propellants. On the other hand, it is difficult to stop and start the burning of a solid propellant. Astronauts on space flights must stop and start the burning of propellant to control the flight of their spacecraft. One method used to stop the burning involves blasting the entire nozzle section from the rocket. But this method prevents restarting.

Solid-propellant rockets are used chiefly by the armed forces. Military rockets must be ready to fire instantly, and solid propellants can be stored better than other kinds of propellants. Solid-propellant rockets provide the power for ICBM's, including Minuteman 2 and MX, and for such smaller missiles as the Hawk, Talos, and Terrier. Solid-propellant rockets are used as boosters for carrier rockets, as JATO rockets, and as sounding rockets. Solid-propellant rockets are also used in fireworks displays.

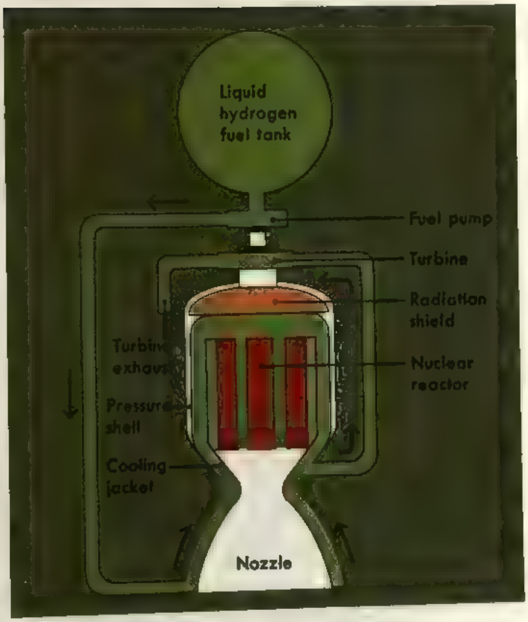
Liquid-propellant rockets burn a mixture of fuel and oxidizer in liquid form. These rockets carry the fuel and the oxidizer in separate tanks. A system of pipes and valves feeds the two propellant elements into the combustion chamber. Either the fuel or the oxidizer flows around the outside of the chamber before blending with the other element. This cools the combustion chamber and preheats the propellant element for combustion.

Methods of feeding the fuel and oxidizer into the combustion chamber include using (1) pumps or (2) high-pressure gas. The most common method uses pumps. Gas produced by burning a small portion of the propellant drives the pumps, which force the fuel and oxidizer into the combustion chamber. In the other method, high-pressure gas forces the fuel and oxidizer into the chamber. The supply of high-pressure gas may come either from nitrogen or some other gas stored under high pressure, or from the burning of a small amount of the propellant.

Some liquid propellants, called *hypergols*, ignite when the fuel and the oxidizer contact each other. But most liquid propellants require an ignition system. An



An ion rocket is a kind of electric rocket. Heating coils in the rocket change a fuel, such as caesium, into a vapour. A hot platinum or tungsten *ionization grid* changes the flowing vapour into a stream of electrically charged particles called *ions.*



A nuclear rocket uses the heat from a nuclear reactor to change a liquid fuel into a gas. Most of the fuel flows through the reactor. Some of the fuel, heated by the nozzle of the rocket, flows through the turbine. The turbine drives the fuel pump.

electric spark may ignite the propellant, or the burning of a small amount of solid propellant in the combustion chamber may do so. Liquid propellants continue to burn as long as the mixture of fuel and oxidizer flows into the combustion chamber.

Thin, high-strength steel or aluminium is used to construct most tanks that hold liquid propellant. Most combustion chambers in these rockets are made of steel or nickel.

Liquid propellants usually produce greater thrust than do equal amounts of solid propellant burned in the same amount of time. It also is easier to start and stop the burning of liquid propellants than that of solid propellants. The burning can be controlled merely by closing or opening valves. But liquid propellants are difficult to handle. If the propellant elements blend without igniting, the resulting mixture will explode easily. Liquid propellants also require more complicated rocket construction than do solid propellants.

Scientists use liquid-propellant rockets for most space launch vehicles. For example, liquid-propellant rockets provided the power for the three stages of the Saturn V launch vehicle.

Electric rockets use electric power to produce thrust. These rockets include (1) arc jet rockets, (2) plasma jet rockets, and (3) ion rockets. Electric rockets can operate much longer than can other rockets, but they produce less thrust. An electric rocket could not lift a spacecraft out of the earth's atmosphere, but it could propel a vehicle through space. Scientists are working to develop electric rockets for long space flights of the future.

Arc jet rockets heat a propellant gas with an electric spark called an *electric arc.* The spark can heat the gas to a temperature three or four times as great as that produced by a solid- or liquid-propellant rocket.

Plasma jet rockets are a type of arc jet rocket. The flow of propellant gas created by an electric arc contains some electrically charged particles. The mixture of the gas and these particles is called a *plasma.* Plasma jet rockets use an electric current and a magnetic field to increase the speed at which the plasma flows from the rocket.

Ion rockets produce thrust with a flow of electrically charged particles called *ions.* A part of the rocket called the *ionization grid* produces ions as a special gas flows over the surface of the grid. An electric field speeds the flow of the ions from the rocket.

Nuclear rockets heat fuel with a *nuclear reactor,* a machine that produces energy by splitting atoms. The heated fuel becomes hot, rapidly expanding gas. Such rockets can produce two or three times more power than do rockets that burn solid or liquid propellant. Scientists are working on the development of nuclear rockets for space travel.

In nuclear rockets, liquid hydrogen is pumped to the reactor through a jacket surrounding the rocket engine. This pumping process helps cool the rocket, and it also preheats the liquid hydrogen. Hundreds of narrow channels pass through the nuclear reactor. As the liquid hydrogen flows through these channels, heat from the reactor changes the fuel into rapidly expanding gas. The gas flows through the exhaust nozzle at speeds of up to 35,400 kilometres per hour.

History

Early rockets. Scientists believe the Chinese invented rockets, but they do not know exactly when. Historians describe "arrows of flying fire"—believed to have been rockets—used by Chinese armies in A.D. 1232. By 1300, the use of rockets had spread throughout much of Asia and Europe. These first rockets burned a substance called *black powder,* which consisted of charcoal, saltpetre, and sulphur. But for several hundred years, the use of rockets in fireworks displays outranked their military use in importance.

During the early 1800's, Colonel William Congreve of the British Army developed rockets that could carry explosives. Some of these rockets weighed as much as 27 kilograms and could travel 2.5 kilometres. British troops used Congreve rockets against the United States Army during the War of 1812. Austria, Russia, and several other countries also developed military rockets during the early 1800's.

Chinese warriors fired rockets in battle during the A.D. 1200's. The use of rockets as weapons and fireworks spread from China throughout much of Asia and Europe during the next century.

An English inventor, William Hale, improved the accuracy of military rockets. He substituted three fins for the long wooden tail that had been used to guide the rocket. United States troops used Hale rockets in the Mexican War (1846-1848). During the American Civil War (1861-1865), each side used rockets.

Rockets of the early 1900's. A Russian secondary-school teacher, Konstantin E. Tsiolkovsky, first stated the correct theory of rocket power. He described his theory in a scientific paper published in 1903. Robert H. Goddard, an American scientist, became the father of the modern rocket. In 1926, Goddard conducted the first successful launch of a liquid-propellant rocket. The rocket climbed 56 metres into the air at a speed of about 97 kilometres per hour.

During the 1930's, rocket research went forward in Germany, the Soviet Union, and the United States. Hermann Oberth led a small group of German engineers and scientists that experimented with rockets. Leading Soviet rocket scientists included F. A. Tsander and I. A. Merkulov. Goddard remained the chief researcher in the United States.

During World War II, German rocketeers under the direction of Wernher von Braun developed the powerful V-2 guided missile. Germany bombarded London and Antwerp, Belgium, with hundreds of V-2's during the last months of the war. American forces captured many V-2 missiles and sent them to the United States for use in research. After the war, von Braun and more than 200 other German scientists went to the United States to continue their rocketry work. Some other German rocket experts went to the Soviet Union.

High-altitude rockets. For several years after World War II, U.S. scientists benefited greatly by conducting experiments with captured German V-2's. These V-2's were the first rockets used for high-altitude research.

The first high-altitude rockets designed and built in the United States included the WAC Corporal, the Aerobee, and the Viking. The 6-metre WAC Corporal reached altitudes of about 72 kilometres during test flights in 1945. Early models of the Aerobee climbed about 120 kilometres. In 1949, the U.S. Navy launched the Viking, an improved liquid-propellant rocket based chiefly on the V-2. The Viking measured more than 14 metres long,

Robert H. Goddard, *left,* a pioneer American rocket scientist, inspects a petrol- and oxygen-powered rocket as his assistants look on. This rocket was built under Goddard's supervision in 1940.

much longer than the Aerobee. But the first models of the Viking rose only about 80 kilometres.

Rockets developed by the U. S. armed forces during the 1950's included the Jupiter and the Pershing. The Jupiter had a range of about 2,570 kilometres, and the Pershing could travel about 725 kilometres. The U.S. Navy conducted the first successful launch of a Polaris underwater missile in 1960. U.S. space scientists later used many military rockets developed during the 1950's as the basis for launch vehicles.

Rocket-powered aeroplanes. On Oct. 14, 1947, Captain Charles E. Yeager of the U.S. Air Force made the first *supersonic* (faster than sound) flight. He flew a rocket-powered aeroplane called the *X-1.* A rocket engine also powered the *Skyrocket,* which set an aeroplane altitude record of 24 kilometres in 1951 and a speed record of 2,132 kilometres per hour in 1953. Another rocket plane, the X-15, raised the altitude record to more than 108 kilometres in 1963. It set the speed record of 7,274 kilometres per hour—more than six times the speed of sound—in 1967. See **Aeroplane** (tables: Altitude records, Speed records—landplanes).

The space age began on Oct. 4, 1957, when the Soviet Union launched the first artificial satellite, *Sputnik I,* with a three-stage rocket. On Jan. 31, 1958, the U.S. Army launched the first American satellite, *Explorer I,* into orbit with a Juno I rocket. On April 12, 1961, a Soviet rocket put an astronaut, Major Yuri A. Gagarin, into orbit around the earth for the first time. On May 5, 1961, a Redstone rocket launched Commander Alan B. Shepard, Jr., the first American to travel in space. On April 12, 1981, the United States launched the rocket-powered Columbia, the first space shuttle to orbit the earth. For more information about rockets in space, see **Space travel.**

Study aids

Related articles in ***World Book*** include:

Artillery
Bazooka
Congreve, Sir William
Goddard, Robert H.
Guided missile
Heat shield
Inertial guidance
Jet propulsion
Rocket, Model
Space travel
Telemetry
Von Braun, Wernher
Yeager, Charles E.

Outline

I. **How rockets work**
  A. Rocket propellant
  B. Multistage rockets
  C. Launching a rocket
II. **How rockets are used**
  A. Military use
  B. Atmospheric research
  C. Launching probes and satellites
  D. Space travel
  E. Other uses
III. **Kinds of rockets**
  A. Solid-propellant rockets
  B. Liquid-propellant rockets
  C. Electric rockets
  D. Nuclear rockets
IV. **History**

Questions

What makes a rocket move?
Where does a rocket get the oxygen it needs?
What is a *multistage rocket*? A *booster*?
What was the contribution of Robert H. Goddard to rocket development? Of Konstantin E. Tsiolkovsky?
What is a *countdown*?
How do jet engines differ from rockets?
What is a *sounding rocket*? A *planetary probe*?
How will scientists use electric rockets?
Who probably invented rockets?
What are the two basic parts of rocket propellant?

Rocket, Model, is a miniature rocket patterned after military or space rockets. Model rockets fly the same way as do the giant space rockets. But the models weigh less than a kilogram, and many of them measure only 20 to 60 centimetres long. Model rockets are also known as *space models.*

The engine of a model rocket produces its power by burning a specially manufactured solid fuel. Model rockets can rise as high as 600 metres in a few seconds, travelling as fast as 480 kilometres an hour. Some kinds of model rockets carry a *payload.* A payload is any small cargo, such as a miniature camera or a radio transmitter. A few model rockets have two or more sections called *stages* assembled on top of one another. Each stage has an engine that starts to operate when the previous stage's engine burns out.

Large numbers of young people and adults build and fly model rockets as a hobby. Most rocketeers build their first rockets from kits sold by model shops.

Model rocketry is a safe hobby, but four main rules must be followed at all times. (1) Rockets must be powered by factory-made engines. (2) Rockets must be built of such lightweight materials as cardboard, plastic, and balsa wood, with no metal structural parts. (3) Rockets must be launched with electrical equipment from a distance of at least 5 metres. (4) The launching device must

Three kinds of model rockets can be built by enthusiasts. A single-stage rocket, *left,* requires less skill and experience to make than a multistage rocket, *centre,* or a glider rocket, *right.*

be pointed within 30 degrees of vertical. In addition, payloads should never include a live animal or a flammable or explosive substance

Parts of a model rocket

Every model rocket has seven basic parts: (1) the body tube, (2) the launch lug, (3) fins, (4) the engine holder, (5) the engine, (6) the nose cone, and (7) the recovery device. A rocket also has a launch system to get it into the air.

The body tube is a hollow cylinder to which all the other parts are attached. Most are made of cardboard.

The launch lug is a narrow paper or plastic tube fastened to the side of the body tube. It fits loosely over the *launch rod,* a long, vertical metal rod that is part of the launch system. During liftoff, the launch lug guides the rocket and keeps it vertical.

Fins help the rocket travel straight during flight. Most model rockets have three or four winglike fins on the bottom of the body tube. The fins are made of cardboard, plastic, or wood.

The engine holder, or *engine mount,* is a cardboard or plastic ring fixed inside the bottom of the body tube. The rocket's engine fits in the holder.

The engine of most rockets consists of a thick cardboard tube that contains the solid fuel. Such an engine can be used only once.

The nose cone forms the top of a model rocket. Its tip has a rounded point that reduces air resistance. Most nose cones are made of plastic or balsa wood.

The recovery device returns the rocket slowly to the ground. One such device is a small parachute made of paper, cloth, or plastic film. It is carried inside the body tube behind the nose cone. At the height of the flight, an ejection charge in the engine forces the nose cone forward and separates it from the body tube. This forward movement also releases the parachute.

The parachute is attached to the nose cone and the body tube by a strong *shock cord* made of rubber or other elastic. This cord prevents the parachute from tearing away from the rocket after the ejection. A wad of cotton or some other flame-resistant material is inserted into the body tube between the parachute and the engine. It protects the parachute from the heat of the ejection charge.

The launch system consists of a launch pad and an engine ignition system. A typical launch pad is made up of a three-legged base, the launch rod, and a deflector. The deflector keeps the engine's hot exhaust gases from coming into contact with the launch pad or the ground.

The ignition system includes a switching device called the *launch controller* and a battery. Wires connect the launch controller to the *igniter,* a special wire inserted into the engine. When the operator presses the launch button of the controller, an electric current from the battery makes the igniter become hot. Heat produced by the igniter starts the engine.

Building and flying model rockets

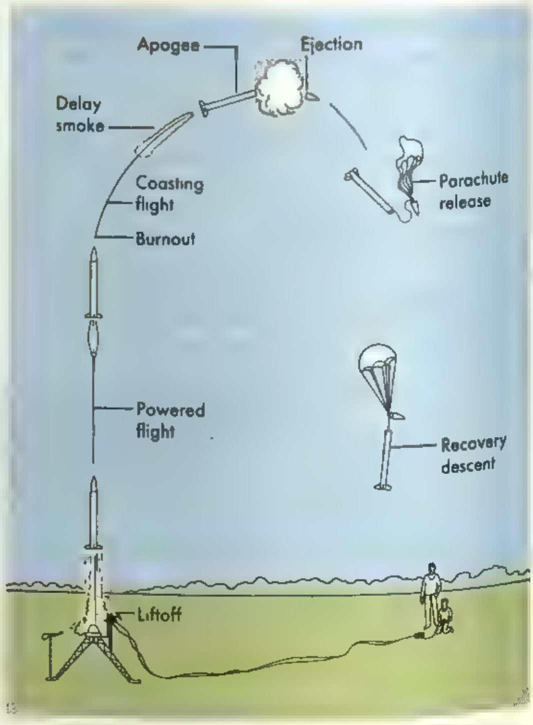
The kits used by many model rocketeers include all parts except the engine and the launch system, which must be purchased separately. Other necessary materials include an adhesive, sandpaper for smoothing the rocket's surfaces, and a sharp knife for cutting out the fins or other parts. Many rocket enthusiasts paint their completed models in order to make them look more realistic.

Before flying a model, a rocketeer should find out if model rocketry is regulated by any laws in his or her area. Next, the rocketeer selects a safe launch site. The site should be a large, open area away from power cables, tall buildings, and trees. It also should be free of anything that could burn easily, such as dead grass, dry weeds, or wastepaper. The length of the shortest side of the site should measure at least a fourth of the highest altitude that the rocket will reach.

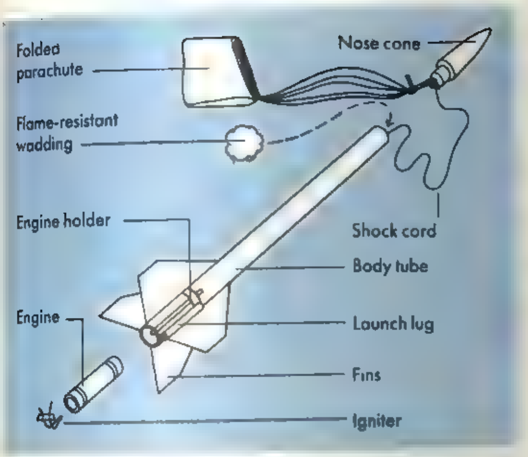
At the launch site, the rocketeer installs the engine and mounts the rocket on the launch pad. After making sure that all spectators are a safe distance from the rocket, the rocketeer calls out a 5-second countdown and presses the launch button. The rocket lifts off and soars into the air. At its maximum altitude, the rocket releases its recovery device and floats to the ground.

Model rocket clubs and competition

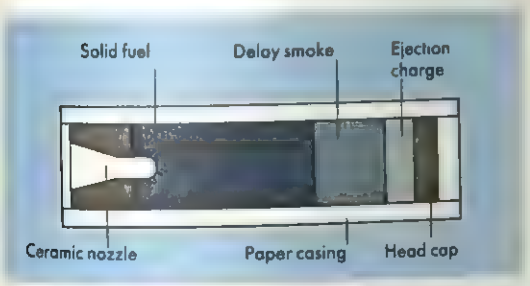
Local model rocket clubs may be formed among almost any group. For example, a club can be part of a church youth group or a scout group. Model rocket clubs should have experienced advisers to help members with projects. The groups also may have their own launch systems and other equipment. Many clubs hold contests. One contest is *egg-lofting,* which involves launching a rocket that carries an egg. Each contestant sends a rocket as high as possible and tries to recover the egg unbroken.



The flight pattern of a model rocket consists of several phases. The rocket's *apogee* (maximum altitude) can be varied by using engines of different sizes.



The basic parts of a model rocket are sold in kits by many model shops. The shops sell rocket engines separately, and a rocketeer can select from a variety of power capacities.



A model rocket engine includes the solid fuel, which propels the rocket. The delay smoke allows it to slow down, and the ejection charge releases the parachute.

Several countries have national model rocket organizations. They set up safety rules, certify model rocket engines, issue publications, and charter local clubs. Through these national associations, model rocketeers can set flight records and become national champions. They can also compete against rocketeers from other countries. The world model rocket championships are held every two years.

Rocket was the first steam locomotive built along the lines of modern engines. Two Englishmen, George and Robert Stephenson, built it in 1829. The *Rocket* reached a speed of 47.5 kilometres per hour on its trial run and proved superior to three rival locomotives.

The locomotive obtained its name, not because of its speed, but because of a comment made in a British engineering journal. The journal said that passengers would be more foolhardy to ride on the train than they would be to ride on a military rocket. The Stephensons took up the journal's challenge and called their engine the *Rocket*.

See also **Locomotive; Stephenson, George.**

Rocket engine. See **Aeroplane** (Rocket engines).

Rockhampton (pop. 59,418), situated on the Tropic of Capricorn in Australia, is the chief commercial and government centre of central Queensland. It stands on the Fitzroy River, about 65 kilometres from its estuary and more than 483 kilometres north of Brisbane. Rockhampton is the outlet for the produce of a rich cattle area and is sometimes called *the beef capital of Australia*. It is also the main centre for the extensive coal-mining and grain areas to the west. Its industries include the manufacture of cement, bricks, precast concrete, flour, and salt, and the processing of meat produce for export. Rockhampton's tourist attractions include historic buildings, botanical gardens, and caves, as well as the Capricorn Coast resorts of Yeppoon, Emu Park, and Great Keppel Island.

Rockhampton, on the Fitzroy River, is the commercial and administrative centre of central Queensland, Australia. It is a rich agricultural and mining area.

Rockingham, Marquess of (1730-1782), a Whig nobleman, was twice prime minister of Britain. He led the Whig administration of 1765 and 1766 that repealed the Stamp Act. This act had angered the North American colonists. In March 1782, after the American War of Independence had been fought and lost, he was prime minister again. But he was already ill, and he died three months after resuming office.

Rocks is a historic area of Sydney, Australia, that has become an important tourist attraction. More than a million people visit the Rocks each year. It is located on a 23-hectare area on the west side of Sydney Cove. The name of the area comes from the rocky hillsides on which it is built.

Convicts who landed with the First Fleet in 1788 built temporary shelters on the site. These shelters have disappeared, but a number of historic buildings have survived and have been restored since 1968 by the Sydney Cove Redevelopment Authority. The oldest building is Cadman's Cottage, which was built in 1816. Campbell's Storehouse was built between 1839 and 1861. Today, it houses restaurants. The Argyle Arts Centre is housed in the old Argyle Stores, which date from 1829.

See also **Cadman's Cottage.**

Rockwell, Norman (1894-1978), was an American illustrator. His paintings of everyday, usually small-town people almost always tell stories, often humorous ones. But they show careful observation and technical skill.

Oil painting on canvas (1950)

Norman Rockwell was a popular American painter and illustrator. Rockwell's painting *Saying Grace, left,* shows his detailed, realistic style. The picture is also an example of the artist's sentimental treatment of scenes from middle-class American life.

Rockwell was a meticulous craftsman, whose works portray homely incidents, well-defined character, and a wealth of supporting detail.

Rockwell gained great popularity as a cover illustrator for *The Saturday Evening Post* and other magazines. He also did art work for many advertisers. He illustrated the "Four Freedoms" of the Atlantic Charter in a well-known series of paintings. Although popular with the public, Rockwell's illustrations were often criticized for their lack of authenticity.

Rockwell was born in New York City. Later, he lived in Arlington, Vermont. He studied at the Chase School of Art, the National Academy of Design, and the Art Students League. His work first appeared in *Boys' Life, St Nicholas, American Boy,* and other magazines and books for children.

Rocky Mountain goat of North America looks like a goat, but it is not a true goat. Like the chamois, it is more closely related to the antelope family. It does not appear to be intelligent, nor as impressive or graceful as the mountain sheep. A suit of dense, woolly underfur with an overcoat of long white hair covers its body. This coat keeps it warm in its cold, windy home high in the mountains where trees will not grow.

The *billy* (male goat) stands from 90 to 105 centimetres at the shoulder and weighs about 90 kilograms. A long beard gives the billy a dignified look. Its slender, backward-curving black horns may be as much as 30 centimetres long. The *nanny* (female goat) has smaller horns and a shorter beard than the billy. Both the billy and nanny have small black hoofs.

The nanny produces one kid, or often twins, in May or June. Mountain goats live in the northern Rocky Mountains from Alaska, south through western Canada as far as Washington, Idaho, and Montana. They eat plants, including grasses and sedges, and the leaves and twigs of shrubs. They are sure-footed climbers on rocky cliffs and slopes. Each male goat prefers to be alone except during the November mating season.

Scientific classification. The Rocky Mountain goat belongs to the bovid family, Bovidae. It is *Oreamnos americanus.*

See also **Animal** (picture: Animals of the mountains).

Rocky Mountain spotted fever. See Rickettsia.

Rocky Mountains are the largest mountain system in North America. The Rocky Mountain Chain extends more than 4,800 kilometres through the United States and Canada. It is about 560 kilometres wide in some places. In the United States, the Rockies stretch through New Mexico, Colorado, Utah, Wyoming, Idaho, Montana, Washington, and Alaska. The Canadian Rockies spread through the provinces of Alberta and British Columbia, and the Northwest Territories and the Yukon Territory.

Visitors to the Rockies enjoy snow-capped peaks,

sparkling lakes, and other magnificent scenery. Several national parks of the United States and Canada are in the Rockies. The region is also famous for its ski resorts and wild game.

The Rockies form the Continental Divide, which separates rivers that flow west to the Pacific Ocean from those going east to the Atlantic Ocean (see **Divide**). The Canadian Rockies also separate rivers flowing north to the Arctic Ocean from those that empty into the Pacific Ocean to the southwest. A number of rivers, including the Arkansas, the Colorado, the Columbia, the Missouri, and the Rio Grande, begin in the Rockies.

Chief ranges of the Rockies include (1) the Southern Rockies, (2) the Middle Rockies, (3) the Northern Rockies, (4) the Canadian Rockies, (5) the Selwyn and Mackenzie mountains, and (6) the Brooks Range.

The Southern Rockies extend from the Sangre de Cristo Range in New Mexico to central Wyoming. They include the highest peaks in the Rocky Mountain System. Wheeler Peak, the highest peak in New Mexico, is 4,011 metres high. Colorado's tallest peak, Mount Elbert, rises 4,399 metres.

The Middle Rockies, which include the Grand Tetons, run from northwestern Colorado and northern Utah to the upper Yellowstone River in Montana. The highest peaks in this range include King's Peak, 4,123 metres high, in Utah; Gannett Peak, 4,207 metres high, in Wyoming; and Granite Peak, 3,901 metres high, in Montana. Yellowstone National Park is in the Middle Rockies.

The Northern Rockies stretch from southern Idaho to the border between the United States and Canada. Borah Peak, the tallest mountain in Idaho, rises 3,859 metres in the Northern Rockies. Glacier National Park lies in this region.

The Canadian Rockies extend from the border north through British Columbia and Alberta. Some of the finest scenic areas of the Rockies lie in Alberta, including Banff and Jasper national parks.

The Selwyn Mountains extend beyond the Liard River in northern Canada. The Mackenzie Range lies east of the Selwyns.

The Brooks Range runs across northern Alaska. Part of the range extends north of the Arctic Circle.

Plant and animal life. Forests of piñon pines and junipers cover the lower slopes of the Rocky Mountains. Firs, pines, and spruces become more abundant as the elevation increases.

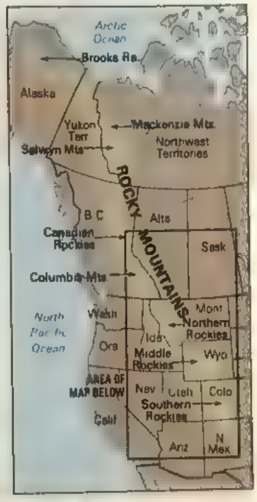
Rocky Mountain goats and bighorn sheep live above the *timber line,* the elevation beyond which trees cannot grow. Bears, deer, hares, elk, minks, mountain lions, porcupines, squirrels, and other animals occupy the higher forested slopes. Chipmunks, coyotes, moose, and muskrats make their homes in the grassy valleys between the mountains. Rainbow trout, grayling, and cutthroat trout are among the fishes that swim in Rocky Mountain streams.

Agriculture and industry. Livestock raising is the main agricultural activity in the Rockies. Cattle and sheep are driven to mountain pastures for the summer and back to the warmer valleys in winter.

Farmers raise chili peppers and pinto beans in the Southern Rockies. Grains, potatoes, sugar beet, and market vegetables are raised in Colorado, Idaho, Montana, and Utah.

Rocky Mountains

The Rocky Mountains extend more than 4,800 kilometres across the western part of North America, from northern Alaska to northern New Mexico. The Rockies are famous for their scenic beauty.



International boundary
State or provincial boundary
Road
Railway
City or town
Mountain pass
Mountain peak

The Rocky Mountains are famous for their majestic peaks and beautiful scenery. The Canadian Rockies tower over the town of Banff in southwestern Alberta, *left.*

The chief industrial activities of the Rockies are mining and timber. The Leadville District and the San Juan Mountains of Colorado produce gold, lead, molybdenum, silver, tungsten, and zinc. The Wyoming Basin, in southwestern Wyoming, is a petroleum and natural gas producing area. It also has coal, oil shale, and uranium deposits. Mines east of Salt Lake City, Utah, produce gold, lead, and silver. Timber and the mining of coal, lead, silver, and zinc are important in the Northern and Canadian Rockies.

Tourism contributes greatly to the economy of the Rocky Mountain states and provinces. Every year, millions of visitors enjoy the region's national parks, ski resorts, and many other attractions.

History. Most peaks of the Rockies were formed millions of years ago during a great upheaval of the earth's crust. The sides of the mountains contain fossils of animals that once lived in the sea, and rocks that were formed in the hot interior of the earth. The southern half of the Rockies includes mountains that were once volcanic plateaus. Through the centuries, the peaks of the Rockies have been cut into various formations by the forces of wind, rain, and glaciers.

Many Indian tribes lived in the Rockies when Europeans first arrived in North America. They included the Navajo, Shoshone, and Ute. The first Europeans to reach the Rockies were Spanish explorers. They established a colony near what is now Santa Fe, New Mexico, as early as 1598.

The American explorers Meriwether Lewis and William Clark travelled through the Northern Rockies in 1805 and 1806. Another American, Zebulon M. Pike, explored the Southern Rockies during this period. Pikes Peak, in central Colorado, was named after him. In the early 1800's, the Rockies became the centre of the American fur trade.

The Rockies hampered transportation during the Westward Movement of the 1800's. However, the Oregon Trail, the longest overland route used by explorers and pioneers, wound through the Rockies (see **Oregon Trail**). The first railway route through the Rockies was built in the Wyoming Basin in 1868. Today, Interstate Highway 80 runs through the basin. Major railway routes also go through the Rockies.

The Eisenhower Memorial Tunnel, west of Denver, is the highest motor-traffic tunnel in the world. The tunnel has an altitude of about 3,400 metres. Moffat Tunnel, one of the longest railway tunnels in the United States, cuts through James Peak, also west of Denver.

Related articles in *World Book* include:

Banff National Park
Bighorn
Rocky Mountain goat
Yellowstone National Park

Rococo is a style of art that flourished in western Europe from about 1700 to 1780. The term comes from a French word for a fanciful rock or shell design. It implies a refined, elegant feeling and style.

Rococo found its fullest expression in France, where the leading representatives were the painters François Boucher, Jean Honoré Fragonard, and Antoine Watteau. They worked primarily for royal and aristocratic clients. Their paintings differed greatly in style and subject matter from those of the preceding baroque period. A typical baroque painting was created on a heroic and grand scale, and usually presented Christian religious subjects. Rococo paintings were intimate in scale and delicate in manner. They often portrayed scenes from classical mythology. Rococo artists also created a new category of painting called the *fête galante*. These paintings showed gatherings of elegantly dressed figures in parks and gardens.

Outside France, there were other artists during this period who worked in a bright lively style characteristic of rococo. They included Giovanni Battista Tiepolo in Italy, and Thomas Gainsborough in England.

The ornate and decorative style of rococo was also applied to architecture, furniture, porcelain, tapestries, and opera and theatre scenery. In architecture, rococo reached its greatest splendour in the palaces, monasteries, and churches of southern Germany and Austria.

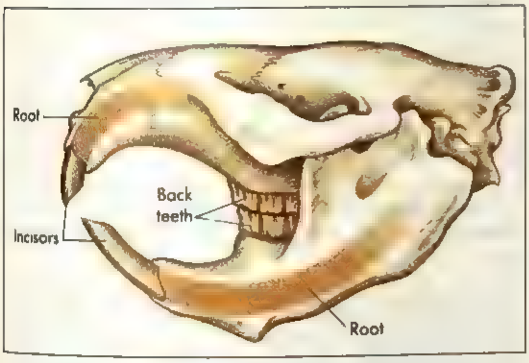
Related articles in *World Book* include:

Architecture (The 1700's)	Furniture (The rococo style; Historical revivals)
Baroque	Painting (The 1600's and 1700's)
Boucher, François	Watteau, Antoine
Fragonard, Jean Honoré	

Rod. See Eye (The retina; diagram).

Rod is a unit of measure in the English system. One rod is equal to $16\frac{1}{2}$ feet, $5\frac{1}{2}$ yards, 5.03 metres, or $\frac{1}{320}$ mile. One square rod is equal to $\frac{1}{160}$ acre, or 0.00253 hectare.

Rodent is an animal with front teeth especially suited to gnawing hard objects. Squirrels, beavers, and rats are rodents. Squirrels can break the shells of nuts with their front teeth. Beavers can gnaw through tree trunks, and rats can gnaw through some wood and plaster walls.



All rodents have chisellike upper and lower front teeth called *incisors.* They can be seen in the beaver skull above.

The many kinds of rodents include voles, hamsters, mice, and porcupines.

All rodents have two top and two bottom front teeth called *incisors.* They wear away at the tips, but do not wear out until late in the animal's lifetime because they keep growing until the animal is old. The incisors wear faster in the back than in front. As a result, they have a chisellike edge, well-suited to gnawing. Rodents also have back teeth consisting of molars and premolars that they use for chewing. The space between the incisors and back teeth is called the *diastema.*

Rodents are *mammals* (animals that feed their young milk). There are more individual rodents than there are individuals of all other kinds of mammals combined. Rodents live in almost all parts of the world.

Mice are the smallest rodents and capybaras of South America are the largest. Some capybaras are over 1 metre long. Most rodents are *herbivorous* (plant eaters). But rats and some other rodents will eat almost any food they can find.

Rodents are both helpful and harmful to people. Some rodents eat harmful insects and weeds, and some have valuable fur. Scientists use mice and rats in research. But some rodents damage crops and other property. Many rodents also carry serious diseases, such as plague and typhus.

Scientific classification. Rodents make up the order Rodentia in the class Mammalia and the phylum Chordata. To learn where the order fits into the animal kingdom, see **Animal** (table: A classification of the animal kingdom).

Related articles. See the following articles on rodents:

Agouti	Guinea pig	Nutria
Beaver	Hamster	Paca
Capybara	Jerboa	Porcupine
Cavy	Jumping mouse	Prairie dog
Chinchilla	Kangaroo rat	Rat
Chipmunk	Lemming	Springhare
Dormouse	Marmot	Squirrel
Flying squirrel	Mountain beaver	Vole
Gerbil	Mouse	Wood rat
Gopher	Muskrat	Woodchuck

Rodenticide. See **Pesticide** (Types of pesticides).

Rodeo is a sport that combines the skills of cowboys and cowgirls with the colour and spirit of the American Old West. The word *rodeo* also refers to a rodeo contest. Rodeos are held in many parts of the United States and Canada, and similar contests are held in Australia.

In rodeo competition, the contestants match their riding and roping skills in rugged, exciting events. Contestants who rank high in an event receive prize money. Rodeo clowns provide additional entertainment.

Rodeo livestock are valuable and receive careful handling. The American Humane Association establishes or approves rules for the care of the livestock.

There are two main groups of rodeo events: (1) rough stock events and (2) timed events. Rough stock events feature cowboys or cowgirls trying to ride bucking horses or bulls for a specified number of seconds. The judges award points to the contestants, chiefly for their form and how well they spur the animals. Timed events are judged according to how quickly the contestants complete the required task.

Most rodeos have three rough stock events and five timed events. The rough stock events are bareback bronc riding, saddle bronc riding, and bull riding. The timed events are calf roping, steer wrestling, team roping, steer roping, and barrel racing.

In most rodeos, only women compete in barrel racing, and only men compete in the other events. But all-girl rodeos include some events that only men enter in other rodeos.

Bareback bronc riding is an event in which the rider must remain mounted for 8 seconds while spurring the horse as it bucks. With one hand, the rider holds onto the *bareback rigging,* a device made of leather that is fastened to the horse like a saddle.

Saddle bronc riding is an event that resembles bareback bronc riding, except that the rider uses a saddle, a halter, and a single rein. The rider must hold the rein in one hand and spur the bucking horse as many times as possible while staying on for 8 or 10 seconds.

Bull riding does not require contestants to spur the animal. They try to remain seated for 8 seconds by holding onto an unknotted rope looped around the bull's belly. They hold the rope with one hand.

Calf roping calls for teamwork between contestants and their horses. A contestant chases the calf on horseback, ropes it, and dismounts. The horse keeps backing up so that the rope is held tight and the calf cannot

Barrel racing is a women's rodeo event in which a contestant rides her horse as fast as she can in a cloverleaf pattern around three barrels. She is penalized for each barrel she knocks over.

Calf roping requires teamwork between a rider and his horse. After lassoing the calf, the rider dismounts to tie the calf's legs. The horse pulls the rope tight to restrain the calf.

break free. The contestant throws the calf to the ground and ties three of its legs together.

Steer wrestling, also called *bulldogging,* is one of two events in which the contestant may have a helper, called a *hazer.* The hazer keeps the steer running in a straight line so the cowboy can jump from his horse onto the steer's back. The cowboy then grabs the steer by its horns and wrestles it to the ground.

Team roping is the only event in which two contestants work together. One contestant ropes a steer's horns, and the other ropes its hind legs. The team finishes when both members have pulled their ropes tight at a 90-degree angle from the steer.

Steer roping is a major event in some rodeos. A contestant on a horse ropes a running steer around its horns from one side. Next, the rider races the horse behind the steer to the other side, causing the steer to trip over the rope. The contestant then dismounts and ties the animal's hind legs together.

Barrel racing is a regular women's event in most rodeos. Each contestant runs her horse in a cloverleaf pattern around three barrels. The judges add 5 seconds to a rider's time for each barrel she knocks over.

All-girl rodeos have some events designed specifically for women and some that resemble men's events at other rodeos. In all-girl rodeos, cowgirls compete in bareback bronc riding and bull riding. They have to remain mounted for 6 seconds and can hold on with two hands. A steer may be substituted for a bull.

Women also compete in barrel racing, team roping, and calf roping. In all-girl rodeos, calf roping is called *tie-down* roping. Cowgirls also compete in *break-away* roping. In this event, a rope is tied to the saddle horn with ribbon or string. After the rider ropes the calf, she stops her horse. The running calf breaks the tie, pulling the rope from the saddle horn.

Cowgirls also compete in *goat tying* and *steer undecorating.* In goat tying, a cowgirl rides up to a goat that is tied to a stake with a long rope. She must trip the goat to the ground and tie three of its legs together. In steer undecorating, a cowgirl on horseback chases a steer that has a ribbon taped to its back. The object is to get the ribbon while the steer is running in a straight line.

History. Rodeo developed from various ranching activities of the late 1800's. For example, after working on a trail drive or roundup, cowboys gathered together and competed in such skills as bronc riding and steer roping. The first rodeo to charge admission to spectators and offer prizes was held in Prescott, Arizona, in 1888.

Cowboys formed the first professional rodeo organization in 1936. Today, professional rodeos in the United States are sponsored by the Professional Rodeo Cowboys Association, by the Girls Rodeo Association, and by the International Rodeo Association. Rodeos for young people are supervised by the Little Britches, by the National High School Rodeo Association, and by the National Intercollegiate Rodeo Association.

See also **Bronco.**

Rodgers, Richard (1902-1979), was a composer for the American musical theatre. He worked chiefly with two great lyric writers, Lorenz Hart and Oscar Hammerstein II. Rodgers' songs include "The Lady Is a Tramp" and "Falling in Love with Love," written with Hart, and "People Will Say We're in Love" and "Some Enchanted Evening," written with Hammerstein.

Rodgers was born in New York City and attended Columbia University. He began to work with Hart on amateur shows in 1919. They achieved their first professional success with *The Garrick Gaieties* (1925). During the 1920's and 1930's, Rodgers and Hart helped make musical comedy into a well-developed art form. Two of their outstanding productions were *On Your Toes* (1936) and *Pal Joey* (1940). See **Hart, Lorenz.**

Shortly before Hart's death in 1943, Rodgers joined with Hammerstein to write *Oklahoma!,* one of the top musicals in history. Rodgers and Hammerstein also created several other shows that rank among the greatest musicals. These works include *Carousel* (1945), *South Pacific* (1949), *The King and I* (1951), and *The Sound of Music* (1959). See **Hammerstein, Oscar, II.**

Rodgers won many awards, including a Pulitzer Prize in drama for *South Pacific* and a special Pulitzer citation for *Oklahoma!* In 1952, he composed the music for *Vic-*

tory at Sea, a TV documentary. He also wrote the music and lyrics for *No Strings* (1962) and the music for *Do I Hear a Waltz?* (1965) and *Rex* (1976).

Rodin, Auguste (1840-1917), is ranked by many as the greatest sculptor of the 1800's. Rodin greatly admired the Italian sculptors Donatello and Michelangelo. Like Michelangelo, Rodin dealt almost entirely with the human figure. Perhaps no sculptor since Michelangelo has created figures with such emotional intensity as Rodin did.

Rodin created an enormous amount of sculpture, and it covers a wide range of human vitality, passion, and suffering. Rodin was primarily a modeller in clay and wax rather than a carver in stone. He built up his forms into irregular, flowing masses and surfaces that carry a vigorous sense of movement to each part. Rodin tried to capture from the living model those fine shades of pose and action that express the individual character of the body. He created many works of art that he deliberately left incomplete or fragmentary. But even these sculptures have a boldness that makes them completely satisfying works in themselves.

Rodin was born in Paris. He did not win public recognition for many years, and had to earn his living designing popular sculpture and sculptural ornament for commercial firms. Indifference and misunderstanding greeted his first exhibits, but appreciation for his work gradually began to spread. By 1880, many influential artists, critics, and public figures had recognized Rodin's genius.

In 1880, Rodin was commissioned by the French government to create a large bronze door for the Museum of Decorative Art in Paris. The subject was the "Inferno" from Dante's *Divine Comedy.* The door was never finished, but Rodin did many plans for it. Later he developed many of them as independent sculptures. The best known include *The Thinker* and *The Kiss.* His most important later works include the monumental group *The Burghers of Calais* and the monument to Balzac. The Balzac statue appears in the **France** (Arts) article. Rodin's *Orpheus* appears in the **Sculpture** article.

Bronze statue (1902-1904); the Rodin Museum, Philadelphia, U.S.A.

Auguste Rodin's *The Thinker,* *above,* is one of the French sculptor's most famous works. Several versions of this statue exist. Like many of Rodin's sculptures, *The Thinker* portrays the human figure in an attitude of great emotional intensity.

Rodney, Baron (1719-1792), George Brydges Rodney, won fame for his naval battles. In 1759, he directed the bombardment of Le Havre and helped to foil the invasion of England by France. In 1782, he captured seven French ships off Dominica, in the West Indies.

Rodney was born in London and educated at Harrow School. He joined the navy in 1732. He became a rear admiral in 1759. He was created Baron Rodney of Stoke-Rodney in 1782. Rodney was governor of Newfoundland from 1748 to 1752.

Rodó, José Enrique (1872?-1917), was a Uruguayan thinker and essayist. He believed in the human spirit's infinite capacity to renew itself, but he feared that humanity was pursuing material goals at the expense of the spirit. Rodó was a leader of the Modernist movement in Spanish literature (see **Latin-American literature** [Modernismo]). In his landmark essay *Ariel* (1900), Rodó urged young Latin Americans to maintain their ideals in their intellectual and spiritual development, avoiding the materialism he claimed was damaging the potential of United States culture. In his philosophical work *Motives of Proteus* (1909), Rodó continued his recommendations for the direction of the mind and spirit. He discouraged the pursuit of technical knowledge in favour of the total cultivation of wisdom. Rodó was born in Montevideo, Uruguay.

Rodrigo Díaz. See **Cid, The.**

Roe. See **Caviar; Spawn.**

Roe, Sir Alliott Verdon- (1877-1958), was the first Englishman to design, build, and fly an aeroplane. He founded A. V. Roe & Company, which became one of the world's largest aircraft firms.

Roe was born in Manchester. He worked for a motorcar company before entering aviation. He made short flights in his aircraft, but did not succeed financially until after Louis Blériot's flight across the English Channel in 1909. Roe formed his aviation company in 1910. The company's most successful aircraft was the Avro 504. Roe was knighted in 1929.

Roe, J. S. (1797-1878), an explorer and surveyor, was surveyor general of Western Australia from 1828 to 1871. He surveyed the sites for the settlements of Perth and Fremantle. He was born in Newbury, England, and educated at Christ's Hospital School, in London. His full name was John Septimus Roe. After settling in Australia, he explored many parts of Western Australia. On his most important expedition, in 1848 and 1849, he explored areas to the southeast of Perth.

Roemer, Olaus. See **Light** (The speed of light).

Roentgen. See **Ion** (Producing ions).

Roentgen, Wilhelm Conrad (1845-1923), a German physicist, won the first Nobel Prize for physics in 1901 for his discovery of X rays. During an experiment in 1895, Roentgen covered a *Crookes tube* (an evacuated glass tube through which an electric current was

passed) with black paper. He noticed that a dark image appeared on a photographic plate substance near the tube when he turned on the electric current.

Roentgen assumed that unknown, invisible rays, which he called *X rays,* were coming from the tube. These rays passed easily through some substances, such as flesh, but were largely stopped by others, such as metal or bone. Because of this, Roentgen found he could photograph the bone structure of his wife's hand.

The use of X rays revolutionized medical and surgical techniques, and provided new insights into the nature of radiation and the structure of the atom. In Germany, X rays were called *Roentgen rays* in his honour.

Roentgen was born in Lennep (now Remscheid), Germany. He was a professor at the University of Würzburg when he made his famous discovery.

See also **Physics** (picture: Wilhelm Roentgen); **X rays.**

Rogers, Will (1879-1935), was an American humorist and social critic. He began his career as a cowboy and rose to world fame as an author, lecturer, and star of vaudeville, films, and radio. Rogers was known for his homespun humour, down-to-earth philosophy, and generosity.

Rogers gained much of his popularity as an easygoing lecturer on current events. During his lectures, he chewed gum and performed rope tricks while kidding about business, government, people, and politics. Rogers also wrote a column that appeared in more than 350 daily newspapers. He began most of his lectures and columns by saying, "All I know is what I read in the papers." Rogers appeared in 50 silent films and 21 talking films and was popular on radio. He wrote six books, including *Illiterate Digest* (1924).

William Penn Adair Rogers was born on a ranch near Oologah in the Indian Territory (now Oklahoma). He was partly of Cherokee Indian ancestry, of which he frequently expressed pride. "My ancestors may not have come over on the *Mayflower,* but they met 'em at the boat," he drawled.

In 1902, Rogers left home to seek adventure in Argentina. That same year, he went to South Africa and joined Texas Jack's Wild West Show as a trick roper. He later toured Australia and New Zealand with the Wirth Brothers' Circus. Rogers returned to the United States in 1904 and began his vaudeville career in 1905 as a trick roper and humorist. He gained fame while appearing on Broadway in the *Ziegfeld Follies of 1916.*

Rogers died in a plane crash near Point Barrow, on the northern coast of Alaska. A statue of Rogers in Claremore, Oklahoma, bears the statement for which he was best known: "I never met a man I didn't like."

Rogers' Rangers scouted for the British Army during the Seven Years' War (1756-1763). Robert Rogers (1731-1795) led the rangers. He won fame as a daring commander whose men would follow him anywhere. But his men were rowdy and undisciplined, and in constant trouble with their superior officers.

Rogers was born in Massachusetts, and served as an Indian trader and explorer. In 1756, he became captain of a company of rangers. By 1758, he had been promoted to major and given command of nine companies. Rogers faced constant financial trouble in later years, and died in poverty. He remained loyal to Great Britain during the American Revolution (1775-1783).

Roget, Peter Mark (1779-1869), was a British doctor and scholar. He became best known as the compiler of Roget's *Thesaurus of English Words and Phrases* (1852). This book has been a source of synonyms ever since its first publication. Roget was born near London. He received a medical degree from the University of Edinburgh, and lectured on anatomy and physiology throughout England. Roget also lectured and wrote about physics, mathematics, and electricity.

Rogun Dam, in Tajikistan, is the highest dam in the world. It stands 335 metres high and is located on the Vakhsh River. The dam was built to provide the Aral-Caspian Lowland region with irrigation water and hydroelectric power. Its reservoir has a capacity of about 13,300,000 cubic metres. The dam has a core of sandy clay that is covered with gravel, crushed rock, and concrete. Construction materials were hauled to the site by a system of conveyor belts stretching 15 kilometres. In addition, workers built 246 kilometres of tunnels and 13 bridges to transport the materials over the rugged terrain. A new city, Rogun, was built to house the construction workers and their families. The Rogun Dam was completed in 1989.

Roland was the greatest of the legendary knights who served the medieval king Charlemagne. Roland's story was first told in *The Song of Roland,* an epic poem written about 1100 by an unknown French author. The work may have been based on an actual event in A.D. 778, but it describes the hero as though he lived in the author's time. In the epic, Roland shows his courage and devotion by accepting the dangerous assignment of protecting Charlemagne's army from the Muslims as it crossed the Pyrenees, a mountain chain between France and Spain. A traitor betrays Roland and his men. They die in battle against the Muslims, but Roland's bravery reflects the knightly ideal of service to one's Lord. Later German and Italian authors also wrote about Roland. Most of their works are longer than *The Song of Roland* and tell a more complicated story.

See also **French literature** (Early French literature).

Roland de la Platière, Marie Jeanne (1754-1793), known as Madame Roland, was a political adviser and hostess to the Girondist group during the French Revolution. She was intelligent, ambitious, and attractive. With her husband, Jean-Marie Roland de la Platière, a minor government official, she took an active interest in the revolutionary movement which began in 1789. By 1791, they had moved from their country home near Lyon to Paris. Jean-Marie Roland was appointed minister of interior under the Girondists in 1792. Madame Roland helped her husband administer this office, and served as hostess to many of the leaders of the Girondists.

Madame Roland felt a strong dislike for certain leaders of the Jacobins, another political group of the time. Her feelings contributed to a struggle for power between the Girondists and the Jacobins. When the Girondist leaders were arrested in June 1793, Madame Roland also went to prison. After a political trial, she was executed by the guillotine in November 1793. Her husband, who had escaped arrest, committed suicide when he learned of her death. The *Memoirs* she wrote in prison explained her beliefs and became very popular. Madame Roland was born in Paris.

See also **Girondists.**

Rolfe, John (1585-1622), an early English settler at Jamestown, Virginia, U.S.A., was married to the famous American Indian princess, Pocahontas. Their marriage in 1614 made the Indians friendly and brought peace to the Jamestown colony.

Rolfe was born in Heachum, England. He was shipwrecked near the Bermuda Islands in 1609 while on his way to Virginia, but he reached there in 1610. He discovered a method of curing tobacco that made it popular in England. As a result, tobacco became the basis of Virginia's economy.

Rolfe took Pocahontas to England, and she died there in 1617. After her death, he returned to Virginia and became a member of the Virginia council. He was killed by Indians in the massacre of 1622. Rolfe and Pocahontas had a son, Thomas.

Roll-on/roll-off ship. See **Ship** (General cargo ships; picture).

Rolland, Romain (1866-1944), a French author, won the 1915 Nobel Prize for literature. His reputation is based on his 10-volume novel *Jean-Christophe* (1904-1912), the story of a young German-born musician. Rolland called the work a *roman-fleuve,* by which he meant that its form corresponded to the unpredictable whims of life, rather than to any preconceived design or plot. In *Jean-Christophe,* Rolland criticized modern civilization and commented on the artist's place in society. The novel expresses Rolland's idealism, his opposition to egotism and hypocrisy, and his love of courage and sincerity. Rolland was born in Clamecy in Burgundy.

Roller is a brightly coloured bird. It looks like a jay, but is more closely related to the motmots and kingfishers. Like them, it has toes which are partially grown together. The roller gets its name from the male's habit of tumbling in the air when it is trying to attract the attention of the female.

The *European roller* is a handsome bird, about 30 centimetres long. It has blue plumage. The tail is greenish blue and black, and the back is a warm chestnut colour. In flight, its wings show vivid blue edged with black. The European roller nests in holes in trees and also in crevices of rocks. It feeds mainly on large insects such as beetles, and also on small vertebrates such as lizards and mice. It drops down on prey from a perch. The European roller spends the summer in southern Europe and the winter in Africa.

Broad-billed rollers feed on insects on the wing, especially on swarming species, such as grasshoppers and termites. The *cuckoo roller* of Madagascar feeds on small lizards on the upper branches of trees.

Scientific classification. Rollers belong to the family Coraciidae. The European roller is *Coracias garrulus.* The broad-billed roller is genus *Eurystomus.* The cuckoo roller is the only member of the family Leptosomatidae. It is *Leptosomus discolor.*

See also **Bird** (picture: Birds of Europe).

Roller skating is a form of recreation and a sport in which people glide on wheeled boots called *roller skates.* Some people skate on pavements and in parks, and others skate to music at indoor rinks. Many take part in competitive roller skating. Joseph Merlin, a Belgian inventor and musical instrument maker, invented the roller skate about 1760.

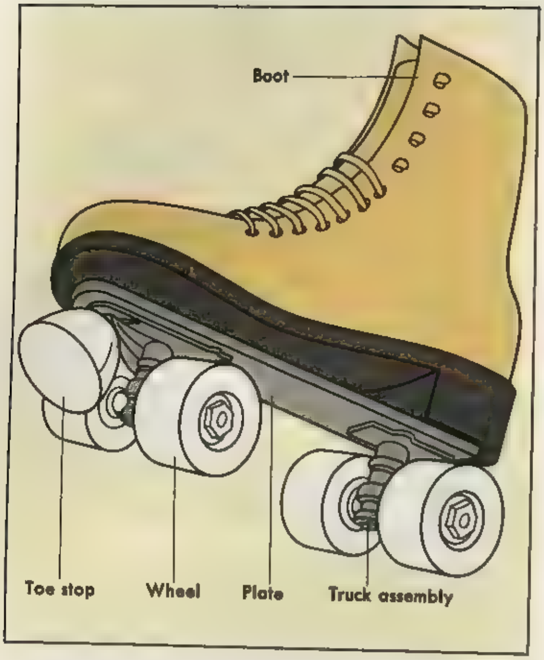
Roller skates. Most roller skates have two major parts, the *boot* and the *skate assembly.* The boots are usually made of leather. Boots worn for recreational and artistic skating have high tops and are laced up the front to a point above the ankle. Speed skaters wear boots with low-cut tops.

The skate assembly is a metal or plastic structure attached to the sole of the boot. Its main parts are the *plate,* two *truck assemblies,* four wheels, and the *toe stop.* The plate is a piece of metal or plastic fastened to the boot. The truck assemblies are attached to the front and back of the plate. They have movable parts that enable skaters to turn corners. A pair of wheels are attached to an axle on each truck assembly. The toe stop is a device at the front of the skate that allows skaters to stop quickly and to perform manoeuvres. Some people wear *clamp-on skates,* which are skate assemblies that

The roller, perched high in a tree, searches for insect prey. The lilac-breasted roller, *above,* lives in Africa south of the Sahara Desert.

Competitive skaters are judged on artistic expression, poise, and technical skill. The couple shown above are competing in *free skating,* in which they perform an original routine.

Parts of a roller skate



they attach to their shoes. Since the mid-1980's, skates with *in-line* wheels have become popular. In-line wheels are arranged one behind the other, resembling an ice skating blade. These skates, commonly called *roller-blades,* are especially used for outdoor skating.

Early roller skate wheels were made of metal or wood. In the mid-1970's, wheels made of a hard plastic called *polyurethane* became popular. Such wheels are quieter than those made of wood or metal, and skaters can move faster and more smoothly on them.

Competitive roller skating includes three types of events. *Artistic skating* and *speed skating* are similar to competitive ice skating (see **Ice skating**). *Roller hockey* combines elements of ice hockey and basketball.

Artistic skating competitors perform graceful movements, often to music. Artistic skating consists of *figure skating, free skating,* and *dance skating.* In figure skating, competitors retrace circular patterns marked on the floor. They are judged on accuracy, timing, smoothness, and control.

Free skating can be performed by an individual or a team. There are separate events for men and women. Individual free skaters, called *singles,* combine jumps, spins, and dance footwork with music. They are judged on the speed, height, and difficulty of their jumps, the speed and form of their spins, the originality of their footwork, and their musical expression. Free skating teams, called *pairs,* consist of one man and one woman. They combine the moves of singles free skaters with lifts and other movements. They are judged by the same standards as singles skaters. But the judges also consider the team's ability to precisely mirror each other's movements. In dance skating, pairs of skaters perform both compulsory dances and an original dance programme to music.

Speed skating has separate events for indoor and outdoor competition. Competitors are divided into nine age groups, with separate races for men and women. Indoor events take place on a flat, 100-metre oval track. Distances for indoor races range from 100 metres to 5,000 metres. Outdoor competitions take place on either a road course or on a banked, oval track. Outdoor events vary in distance from 300 metres to 20,000 metres. There are also indoor and outdoor relay events for teams of two, three, or four skaters.

Roller hockey is a noncontact team sport. Teams consist of four "floor" players and a goalkeeper. Players score points by passing a hard plastic ball into the opponent's goal. They move the ball along the ground with short, curved sticks like those used in ice hockey.

Rolling Stones are a popular English rock band. The band's music has often been aggressive, rebellious, and sexual. The group is known for the excitement of its live performances.

The Rolling Stones were formed in 1962 and took their name from a song by the American blues singer Muddy Waters. The original members of the group were lead singer Mick Jagger (1943-), guitarists Keith Richards (1943-) and Brian Jones (1942-1969), bassist Bill Wyman (1936-), and drummer Charlie Watts (1941-). Jones left the band in 1969, shortly before his death. He was replaced by guitarist Mick Taylor, who quit the group in 1974. Ron Wood has been the Stones's second guitarist since then.

The band was formed to play the music of earlier blues and rock artists. But Jagger and Richard soon began writing most of the band's material. Their hit songs include "(I Can't Get No) Satisfaction" (1965), "Get Off of My Cloud" (1965), "Honky Tonk Women" (1969), "Brown Sugar" (1971), and "Start Me Up" (1981).

In the 1980's, the individual members of the Rolling Stones began involving themselves in solo projects. Jagger recorded "Dancing in the Street" with the English rock performer David Bowie in 1985. Jagger's solo record "Just Another Night" from his album *She's the Boss* also became popular that year. The group appeared in several filmed versions of their concerts.

Rollright Stones are about 60 stone pillars forming a circle about 30 metres in diameter. They stand on a hill above the village of Long Compton, in Oxfordshire, England. They are also called the *King's Men.* The largest stone in the circle is over 2 metres tall. The Rollright Stones date from the early Bronze Age. Nearby are the remains of a burial chamber of the same period known as the *Whispering Knights.*

Rolls, Charles Stewart (1877-1910), was a cofounder of the engineering firm of Rolls-Royce. In 1904, Rolls and Frederick Royce merged their companies to manufacture high-quality motorcars (see **Royce, Sir Henry**). Royce designed the cars, and Rolls sold them.

Rolls was born in London. He was educated at Eton and Cambridge.

Roma (pop. 6,220), a town in southern Queensland, Australia, is noted for its reserves of natural gas. Oil was first discovered in the area in the early 1900's, but natural gas in commercial quantities was not found until the 1960's. In Roma in 1961, natural gas was used to generate electricity for the first time in Australia. The natural gas is now piped from the fields over 450 kilometres to Brisbane.

Romains, Jules (1885-1972), was the pen name of Louis Farigoule, a French novelist, philosopher, and dramatist. He is best known for his series of 27 interrelated novels published between 1932 and 1947 under the overall title *Men of Good Will.* The novels present a panoramic view of French life between 1908 and 1933. They follow more than 400 characters as they are caught up in world events and in each other's lives. The series shows how all aspects of life, large and small, are intertwined. Romains called this sense that everything in life is related *unanimism.* He believed that it was more profitable to examine the movements and experiences of groups than of individuals.

The best-known of Romains' plays is the satirical comedy *Dr. Knock* (1923) about a successful, fraudulent doctor. Romains also wrote poetry and political and philosophical studies. He was born in Saint-Julien-Chapteuil, near Le Puy.

Roman alphabet. See **Alphabet** (The Roman alphabet).

Roman Britain. See **United Kingdom, History of the** (Roman Britain [55 B.C.-A.D. 410]).

Roman calendar. See **Calendar** (History).

Roman Catholic Church is the largest body of Christians in the world. In fact, the church has more followers than all other Christian groups combined and more than any non-Christian religion. About 1 billion people—nearly a fifth of the world's population—are followers of the Roman Catholic faith.

Roman Catholics believe that Jesus Christ founded their church to carry to all people the salvation He brought to the world. Catholics also believe that, through God's protection, the church has preserved the teachings of Christ. According to Catholic teaching, the Holy Spirit, sent by Christ to humanity, guides the church.

The pope, who is the bishop of Rome, serves as spiritual leader of the Roman Catholic Church. He governs the church from Vatican City, a tiny independent state within the city of Rome. A group of departments called the *Roman Curia* assists the pope in his direction and guidance of the worldwide church. Members of the clergy throughout the world serve the religious needs of Catholics in their particular areas.

Most Roman Catholics live in Europe, North America, and South America. In France, the Republic of Ireland, Italy, Spain, and almost all Latin-American countries, nearly all the people belong to the church. The church operates schools, universities, hospitals, orphanages, and homes for the aged in these and other countries with large Catholic populations. In a few nations, Catholics have formed strong political parties.

The Roman Catholic Church has been an important force in world history. During much of the Middle Ages, for example, the church had great political power in Western Europe. Its universities and monasteries became centres of medieval learning. During the 1500's and 1600's, Catholic missionaries travelled to the New World, Africa, and Asia, where they played an important role in spreading Western culture.

Throughout its history, Catholicism has influenced the development of the arts. Church art has served both as decoration and as a means of expressing and teaching religious ideas. Many works of architecture, literature, music, painting, and sculpture have been inspired by Catholic beliefs or created with church support. These works include the soaring Gothic cathedrals built in France during the Middle Ages and the Italian poet Dante Alighieri's masterpiece, the *Divine Comedy* (1321). Other works include the magnificent frescoes painted in the Vatican during the early 1500's by the great Italian artists Michelangelo and Raphael.

Roman Catholic beliefs

To Catholics, religious faith means, above all else, a response to God. The Lord offers Himself to people in friendship and love, and people respond by giving themselves totally to God. A Catholic's basic faith in God involves certain doctrines. Catholics believe that these doctrines are true because the Bible and the church's tradition are an assurance that God has revealed them. These teachings can be found in declarations by church councils and popes, and in short statements called *creeds.* The most important creeds include the Apostles' Creed; the Nicene Creed; the Athanasian Creed; the Creed of Pius IV; and the Creed of the People of God, set forth by Pope Paul VI. These creeds summarize Catholic doctrines on (1) the Trinity and creation; (2) sin and salvation; (3) the nature of the church; and (4) life after death. These doctrines, in turn, form the basis of Catholic morality.

The Trinity and creation. Catholics believe there is only one God. But in this God there are three Persons—the Father; the Son, who is Christ; and the Holy Spirit. These three Persons form the *Trinity.* Each Person is distinct and is truly God. Yet there is only one God, who has no beginning or end, is beyond time and space, and is perfect and changeless. Catholics believe that the universe owes its beginning to God, who created everything freely, from love. They are convinced that humanity and its world could not survive without God's continuing care.

Sin and salvation. The Catholic Church teaches that humanity was created not only *by* God but also *for* God. Its destiny is to share God's life for eternity. God intended humanity to achieve this destiny by lovingly obeying His will. But the *original sin* interfered with God's plan for humanity. The Bible describes Adam, the first man, as committing this sin by an act of disobedience to God. Adam's sin passes on to each child born in the world.

Catholics believe that God sent His Son, the second Person of the Trinity, to save humanity from all sin, both from the original sin that individuals inherit, and also from the sins they commit during their lifetime by deliberately breaking God's law. Without ceasing to be God, the Son of God was born in human form to the Virgin Mary. He saved humanity through His life and death and by rising from the dead and passing into heaven. While on earth, Jesus taught that salvation would be given to all who believe and are sincerely sorry for their sins.

The nature of the church. Salvation was not complete when Christ left the earth. Salvation had to be brought to each new generation. Jesus therefore commissioned His apostles to gather all human beings into a church. Catholics describe this church as the people of God, united with Him and one another through Christ. They also consider the church to be a missionary peo-

The Mass, or Eucharist, is the central act of worship in the Roman Catholic Church. In this picture, a cardinal celebrates Mass at St. Patrick's Cathedral in New York City.

ple with the function of drawing everyone into a communion of love. Catholics believe their church has preserved to a greater extent than has any other Christian body the doctrine, organization, and worship willed by Jesus. But Catholics do not deny that other churches are also communities of grace and salvation.

Life after death. According to Catholic doctrine, life does not end with the death of the body. Instead, the soul leaves the body and goes to heaven, purgatory, or hell. On Judgment Day, when this world has ended, all souls will be reunited with their bodies.

Heaven is the community of those who have reached their destiny. They see God as He is and they love Him with complete joy. Purgatory is a temporary state for souls who die in God's love but must be purified of any remaining imperfections and/or make amends for sins already forgiven. The church defines hell as the endless absence of God, which means complete despair. It is the punishment for people who have rejected God through the enormity of their unforgiven sins.

Catholic morality—that is, the measure of right conduct—is only partly expressed in such negative commandments as do not kill, lie, or steal. Instead, Roman Catholic morality can be largely summarized in a positive statement. The church tells Catholics to love God with their whole heart and to love their fellow human beings as they love themselves. The Roman Catholic Church believes that all people must follow their consciences. But a Catholic's conscience is formed not only by personal opinion of what is right and wrong. It is also formed by the Bible's teachings, by instructions from the church, and by the faith and conduct of the Christian community.

Worship and liturgy

Catholics worship only God. But they also have deep respect for holy people closely related to God, especially Mary, the mother of Jesus. Catholics also show respect for holy places and objects, such as Bethlehem, the birthplace of Jesus, and the cross on which Christ was crucified.

The acts of worship that Catholics perform together are called the *liturgy.* The central act of the liturgy is the *Eucharist,* also called the *Mass.* Other important liturgical acts include the seven sacraments and various sacramentals.

The Eucharist, or Mass, is a celebration of the Lord's Supper. According to Catholic teaching, the priest, acting in Jesus' name and with His power, changes bread and wine into Christ's body and blood, which the people receive in Holy Communion. Catholics also believe the Mass presents again the sacrifice Christ offered of Himself.

In the Mass, sins are forgiven, God's help is given, and the members of the congregation are closely united with their fellow human beings. Catholics must take part in the Mass on Saturday evenings or Sundays and on *holy days of obligation,* such as Christmas.

The Mass has two main divisions. The first division, the *liturgy of the word,* proclaims the message of the Gospel. It consists of a petition for forgiveness of sins, hymns, prayers, Bible readings, a sermon, and a declaration of faith. The second division of the Mass, the *Eucharistic liturgy,* has two parts. In the first part, the gifts of bread and wine are offered to God and are changed into the body and blood of Christ. The most solemn moment is the recitation of Jesus' words at the Last Supper: "This is my body . . . this is the cup of my blood." In the second part of the Eucharistic liturgy, the congregation receives Christ in Holy Communion. In receiving Communion, Roman Catholics eat the body of Jesus Christ and drink His blood in the appearances of bread and wine.

The seven sacraments are ceremonial signs of

God's action in people's lives. These signs take the form of words and gestures that are symbols of grace from God. The sacraments of the Roman Catholic Church are (1) baptism; (2) confirmation; (3) Eucharist; (4) penance; (5) holy orders; (6) marriage; and (7) anointing of the sick.

Baptism is a ceremony in which a child or adult is cleansed of sin to begin a new life with God. Water poured, in the name of the Trinity, over the head of the person being baptized is a sign of the person's cleansing from sin. Because water is necessary to life, the baptismal water also is a sign of new spiritual life. Baptism also marks the beginning of a Catholic's oneness with Christ and entry into the church.

Confirmation is a sign of a new outpouring of the Holy Spirit. It enables baptized people to grow to spiritual adulthood so that they can bear Christian witness with courage. During confirmation, a bishop, and sometimes a priest, puts holy oil, called *chrism,* on the forehead of the person being confirmed.

Eucharist, or *Mass,* is the central act of Catholics' worship of God. This sacrament reenacts the death and resurrection of Jesus Christ in ritual form. In Holy Communion people receive the body and blood of Christ in the appearances of bread and wine.

Penance, also called *confession,* is a sacrament in which Roman Catholics confess their sins to a priest, express their sincere sorrow for having sinned, and promise to try not to sin in the future. The priest forgives the sinner in God's name. The effect of penance is to reconcile the Roman Catholic to God and to the Christian community.

Holy orders is the sacrament in which men chosen by the church are made deacons, priests, or bishops. They become ministers of God's word and sacraments.

Marriage is the sacrament in which a man and woman promise themselves to each other for life. This sacrament helps them be faithful to the duties of marriage and family life.

Anointing of the sick is a sacrament given to people who are dangerously ill or very old. The priest anoints the person with oil, a sign of curing. The priest prays that the person will receive the grace of the Holy Spirit, so he or she may be freed from sin, comforted and strengthened in soul, and restored to health.

The sacraments of baptism, confirmation, and holy orders may be received only once. In general, a Catholic man and woman may also marry only once, unless one of the partners dies. Anointing of the sick may be repeated if the person becomes ill again or the danger becomes more acute. Holy Communion must be taken at least once a year, at Easter time. Catholics must also confess their sins at least once a year if the sins are serious. However, the church urges believers to receive both Eucharist and penance more frequently.

Sacramentals are holy ceremonies that have two purposes. They prepare for and prolong what the sacraments do, and they raise the tone of everyday living into something sacred. Popular sacramentals include the blessing of a harvest or a new school, and blessings of fishing boats, wedding rings, and cars.

Church organization

The organization of the Roman Catholic Church can be described in terms of the roles of the church and its members. These roles include (1) the church's functions; (2) the role of the clergy; and (3) the role of the laity.

The church's functions. The church has three closely related functions. (1) It helps people become and remain holy by the ministry of preaching and worship. (2) It teaches God's truths by such means as religious education. (3) It guides people toward God by means of wise laws.

The role of the clergy. The clergy's special responsibilities are leadership and service. They conduct the liturgy of the sacraments, such as presiding at the Eucharist. They preach and give religious instruction. They also hold official positions and respond to the spiritual needs of their people. There are three *orders* (ranks) within the clergy—bishops, priests, and deacons. The organization of the clergy by rank is called the church's *hierarchy.* Each order—from deacons up through the pope—has more responsibilities and wider powers of ministry and government than the one below it.

The role of the laity. The laity's special role is to be a witness to their faith—that is, to live according to the principles of their faith—at all times. The laity have an active role in the total function of the church. They become joined with the clergy in worship and prayer. They also teach others by their good example. The laity elect lay members to such governing bodies as parish councils and parish school boards. At Mass, some lay people act as readers of selections from the Bible. Others distribute Holy Communion. Some lay people work as teachers in a Catholic school, and others give religious instruction to Catholic students who attend public schools. Lay people also hold important positions in church-owned hospitals and other institutions.

Church government

The hierarchy of the church has three levels: the pope holds responsibility for the whole church, a bishop for a diocese, and a pastor for a parish. The pope appoints bishops who in turn appoint pastors.

The pope, who is the bishop of Rome, holds the church's highest office. Catholics believe that he is Jesus' representative on earth and a successor to St. Peter, the first pope. They regard him as the spiritual leader of the worldwide church.

Cardinals are generally clergymen. They are appointed by the pope to be his main advisers. As a group, they form what is called the College of Cardinals. They have the responsibility of electing a new pope, when necessary.

The Roman Curia serves as the pope's administrative arm. The Curia consists of the Secretariat of State and a number of other departments called congregations, secretariats, tribunals, and offices. Many cardinals work in the various departments of the Curia.

The Secretariat of State assists the pope most directly in governing the church and in communicating with the rest of the Curia. The various congregations carry on most of the Curia's administrative work. For example, the Congregation for the Evangelization of Peoples or Propagation of the Faith supervises missionary activity. The secretariats deal with matters of Christian unity and handle relations with non-Christians and with people who do not believe in God. Tribunals have judicial powers. For example, the tribunal called the Sacred Roman Rota

serves as a court to settle disputes about the validity of marriages. The various offices are responsible for such functions as drafting papal letters and documents and gathering statistics about the church.

Bishops are considered successors of the apostles. The pope appoints bishops, and they are responsible to him. The *body of bishops* consists of all the church's bishops, including the pope as a member and its head. The body of bishops, like the pope, has responsibility to teach and guide the church as a whole. For example, the body of bishops that met at Vatican Council II (1962-1965) issued 16 historic statements. These statements had great impact on church policy concerning such subjects as religious freedom, relations between Catholics and other Christians, and the role of the church in the modern world. For a discussion of the 16 statements, see **Vatican Council.**

Dioceses and parishes. A diocese is a territorial district of the church. Catholics who live in a territory are said to belong to the diocese. A bishop called the *Ordinary* is the spiritual leader of a diocese. In large dioceses, the Ordinary has the assistance of other bishops called *auxiliary bishops.* Many church-supported agencies, including hospitals, newspapers, and schools, serve local needs in a diocese.

A diocese is divided into parishes. A *territorial* parish includes all Catholic residents in a given area. A *national* parish primarily serves an ethnic group whose members may live in several territorial parishes. Catholics belong to the parish in which they have stable residence. Active parishioners faithfully perform their religious duties and participate in parish events. The pastor of a parish is its spiritual leader. Pastors of large parishes are assisted by associate pastors.

Religious institutes are societies of Catholic men or women who live together under a set of regulations called a *rule.* They take vows of poverty, chastity, and obedience. Well-known Catholic institutes for men include the Jesuits, the Franciscans, and the Dominicans. Institutes for women include the Sisters of Charity and the Ursulines. Religious institutes are governed directly by their own appointed or elected leaders. These leaders are called *superiors.*

The early church

The first 300 years. Catholics trace the beginnings of their church to Palestine. There, according to the Bible, Christ told the apostles to preach the gospel to all peoples. In Jerusalem, the Holy Spirit came upon the earliest believers.

The first Christians were Jews who believed that Jesus was the *Messiah,* the saviour expected by the Jews. The early church gradually divorced itself from Judaism, the religion of the Jews. However, the church accepted the Jewish Scriptures, both as the record of God's dealings with His chosen people and as a guide leading to Jesus Christ.

Saint Paul became the most important person to carry the gospel to the *gentiles* (non-Jews). He regarded himself as a divinely appointed apostle to the gentiles. Paul founded many churches and exercised authority over them through visits and letters. He also represented their interests with the mother church in Jerusalem. After Paul's death, about A.D. 67, the number of gentile churches continued to expand rapidly. By about 140, the centre of Christianity had passed from Jerusalem to Christian communities in the cities of Antioch in Syria, Alexandria in Egypt, and especially Rome.

During the first three centuries, the church grew steadily in spite of persecution by the Romans, whose empire covered most of Europe, the Middle East, and northern Africa. The Romans believed that loyalty to the emperor involved honouring the gods of the state and often the emperor. They regarded Christians who refused to give such honour as traitors and atheists. The Christian ideal became the *martyr*—a person who suffered persecution and even death rather than abandon Christianity. Although the church suffered widespread persecution, many of these attacks were local and brief. The church thus had time to grow and improve its organization.

While the church faced persecution from outside, many movements threatened to divide it from within. Some of these movements taught what the church declared to be *heresies*—that is, teachings opposed to basic Christian beliefs. The most serious heresy during the church's first 200 years was *Gnosticism.* It was a religious philosophy that had many followers throughout the Roman Empire. The successful struggle against Gnosticism has been called the most difficult and important battle in church history. See **Gnosticism.**

The earliest Christians relied on the apostles, led by Saint Peter, as their authority in settling questions of doctrine and government. After the death of the apostles, the church faced the problem of where to turn for authority in such matters. In the 100's, two developments helped solve the problem. First, the church gradually recognized the books of the New Testament as sources of authority in doctrine. Second, the basic orders of Christian ministry—bishops, presbyters, and deacons—became more clearly defined. In time, presbyters became known as priests. Local councils of bishops strengthened church unity by discussing and sometimes settling many issues, from the date of Easter to the immortality of the soul.

The recognition of Christianity. Constantine the Great was the first Roman emperor to become a Christian. In 313, Constantine and Licinius, the emperor of Rome's eastern provinces, granted freedom of worship and equal rights to all religious groups in the empire. By the late 300's, Christianity had become a favoured religion of the empire.

The recognition of Christianity had some unfortunate effects on the church. For the first time, the church attracted many people who lacked the dedication of the early Christians. Emperors intruded into the internal affairs of the church. In the mid-300's, for example, the Roman Emperor Constantius II tried to force the Eastern heresy known as *Arianism* on the West. Arianism is named after Arius, a priest in Egypt who claimed that Christ was not truly God (see **Arianism**).

But on the whole, the empire's recognition of Christianity benefited the church. The church was able to influence civil laws. The church also expanded its work among the poor and began missionary activities outside the empire.

Bishops from throughout the Christian world met several times to resolve major theological disputes in the

Fresco (1481) by Perugino; Sistine Chapel, The Vatican, Rome

The first pope, in Catholic doctrine, was Saint Peter. This painting shows Jesus presenting the kneeling Peter with the keys to the kingdom of heaven, which symbolize the office of the pope.

early church. These meetings are called *general* or *ecumenical councils.* The first council, Nicaea I, met in 325 and condemned the teachings of Arius. In 381, the first Council of Constantinople also took a stand against Arianism. The Council of Ephesus in 431 condemned the teachings of Nestorius, the *patriarch* (bishop) of Constantinople. Nestorius asserted that Mary was the mother of Christ but not the mother of God. In 451, the Council of Chalcedon denounced *Monophysitism,* which in its heretical form did not keep distinct and complete the two natures of Christ.

Some of the most distinguished literature in church history was produced between 325 and 451. The most notable writers of this period included the historian Eusebius, the bishop Saint Athanasius, the theologian Saint Augustine, the preacher Saint John Chrysostom, the poets Saint Ephrem and Prudentius, and the Biblical scholar Saint Jerome. The writings of these men had a great influence on church thought in later centuries.

Monasticism began to develop in the 300's. This way of life, in which a person withdraws from worldly affairs and is completely devoted to religion, was to play an important part in church history. As persecution ceased and Christianity prospered, the monk replaced the martyr as the Christian ideal. The two basic models for future monastic life were the Egyptians Saint Anthony and Saint Pachomius. Anthony lived the solitary life of a hermit. Pachomius organized monastic communities governed by a rule.

Pope Saint Leo I, who reigned from 440 to 461, was perhaps the greatest pope in early church history. Leo persuaded the Huns and the Vandals, two barbarian tribes, to halt their attacks on Italy. By the time Leo began his reign, the huge Roman Empire had been split into Eastern and Western empires. Leo emphasized that popes were successors to Saint Peter and so had *primacy* (supreme authority) as head of the universal church.

Conflict with the East. Before the 400's, a single Christian church existed. But it consisted of several nationalities. Each nationality expressed the Christian faith in its own language and liturgy and, at times, its own theology. Gradually, cultural, geographic, political, and religious differences led to the development of several separate churches in the East Roman Empire. Beginning in the 400's, the Eastern churches began to drift away from the authority of Rome and from the church in the West.

Several events helped widen the gulf between Western and Eastern Christianity. One event was the condemnation of the teachings of Patriarch Nestorius by the Council of Ephesus. Later, in reaction, the East Syrian Church separated itself from the Western Church. The gulf widened after the Council of Chalcedon condemned Monophysitism, which had many followers in the East. After this condemnation, the Armenian Church, the Coptic Church of Egypt, the Ethiopian Church, and the Syrian Jacobite Church all broke away from those churches that accepted the teaching of the Council of Chalcedon.

The Middle Ages

In A.D. 476, barbarian forces led by the Germanic general Odoacer deposed the last emperor of the West Roman Empire. Many historians use this date to mark the end of the Roman Empire in the West and the start

of the Middle Ages. During the Middle Ages, the influence and power of the church reached their peak.

The collapse of the West Roman Empire meant that no one power had political control in the West. Instead, all of Western Europe except Ireland came to be ruled by barbarian kings, who were either Arians or non-Christians. Beginning with the reign of Pope Gregory the Great in 590, the church set out to create a Christian world in the West. Its chief instruments were the papacy and monasticism.

The papacy gradually replaced the empire as the centre of authority in Western Europe. Ireland had been converted to Christianity in the 400's, mainly through the efforts of Saint Patrick. In 496, the king of the Franks, Clovis I, was converted. His conversion brought Gaul into the church and checked the spread of the Arian heresy there. Gaul was a huge region now occupied mainly by Belgium, France, and part of western Germany. From the 500's to the 700's, the papacy directed the conversion of other peoples of the West. These peoples included the Visigoths in Spain, the Anglo-Saxons in England, and the Magyars in central Europe.

Monasticism. Meanwhile, the growth of monasticism played a large part in the increasing influence of the church. Monasticism created centres of Christian society, renewed the spiritual life of religious communities, and helped transform a dying Western culture into a Christian civilization. In the early 500's, Saint Benedict of Nursia founded Benedictine monasticism. The Benedictine rule was both moderate and humane in setting forth how its followers should live. These qualities influenced the rule of many later orders.

In the early 700's, Muslims, who followed the religion of Islam, conquered Spain. Also in the 700's, Viking raiders from northern Europe began to attack England and other Christian countries. The conquest of Spain and the Viking attacks greatly disrupted Western European economic, political, and social life. In the midst of these disruptions, the church stood out as the major force for unifying and civilizing the West.

Charlemagne, the greatest king of the Franks, became one of the most important people in European as well as church history. During his reign, he laid a foundation for the organized, civilized society later built in Western Europe. This foundation resulted from the ideals that Charlemagne pursued—orderly government, religious reform, and the expansion of the Christian world through conquest and missionary activity.

Charlemagne involved himself in church affairs and became protector of the popes. In 800, Pope Leo III crowned Charlemagne emperor of the Romans, restoring the idea of empire in the West. Charlemagne's empire formed the basis of what became the Holy Roman Empire in 962. The Holy Roman Empire lasted until 1806. It consisted largely of German and Italian states ruled by German emperors. See **Holy Roman Empire.**

Cluniac reform was the name given to a vast reform movement within the church. This movement began during the 900's and lasted about 200 years. It was centred in the Benedictine abbey of Cluny, France. The movement introduced significant changes in the way monasteries were governed and monks lived. It also helped correct abuses within the church, such as *simony* (buying or selling sacred things or church offices). The Cistercian order—founded in 1098 in Cîteaux, France—also became a leading force for church renewal, particularly under the leadership of Saint Bernard of Clairvaux.

Split with the East. Since the 400's, the Eastern churches had continued to drift away from the church in the West. Then, in the 800's, Photius, patriarch of Constantinople, had a serious dispute with the papacy. A major issue in the dispute was the pope's claim to authority over Eastern Christians. In the 1000's, another dispute developed between Rome and the patriarch of Constantinople, Michael Cerularius. Part of this dispute arose from claims by each church that the other was interfering in its affairs. Serious splits emerged from these disputes. The disputes led to a formal division between the Eastern churches that employed the Byzantine rite and the Western church that followed the Latin rite and acknowledged the primacy of the bishop of Rome. However, some Eastern churches eventually reunited with the Roman Catholic Church, forming what are now called the Eastern Catholic Churches. See **Eastern Orthodox Churches.**

Innocent III became pope in 1198. Under Innocent, papal influence over public life in Christian Europe reached its peak. He was feudal lord over much of Europe, and he was a great administrator and jurist. In 1215, he called one of the greatest councils of the Middle Ages, the Fourth Lateran Council. The council's 70 *decrees* (rulings) on subjects such as the Eucharist and certain powerful heresies influenced church government, liturgy, and teaching for centuries.

Innocent died in 1216. But his reign laid the groundwork for the founding of the Dominican order later that year. It also led to the establishment of the religious court called the *Inquisition* in 1231 (see **Inquisition**). Both institutions were effective in fighting heresy.

Scholasticism. During the 1100's, the system of thought called *medieval scholasticism* began to develop. It reached its peak in the 1200's. Its scholars, called *scholastics,* tried to reach a better understanding of Christian doctrine by the use of reason, especially philosophy. They put various doctrines and the explanations of those doctrines into systematic order. They also tried to resolve conflicting viewpoints in Christian theology. The leading scholastics included Saint Albertus Magnus of Germany, Roger Bacon of England, Saint Bonaventure of Italy, and especially Saint Thomas Aquinas of Italy. The centre of scholasticism was the University of Paris, one of several universities established in Western Europe by the church during the 1100's and 1200's. See **Scholasticism.**

Boniface VIII became pope in 1294. He tried to unify the Christian world more closely under the papacy. Boniface insisted that kings of individual nations were subject to the Holy Roman emperor and that the emperor's power, in turn, came from the pope. In 1302, Boniface issued a *bull* (papal decree) of immense importance. This bull, called *Unam sanctam,* stated that "two swords" served the church. One sword was the spiritual power of priests. The other was the *temporal* (non-religious) power of rulers. The bull declared that, for salvation, every human being must be subject to the pope. Catholic theologians no longer regard the Unam sanctam as church doctrine.

The Avignon papacy. In 1309, the pope moved from Rome to Avignon, in what is now France. The popes did not return to Rome until 1377. The popes lived in Avignon for several reasons. One of the most important was the desire to avoid the civil wars that were disrupting Italy in the 1300's. During the Avignon period, the machinery of papal government was strengthened and reform efforts continued. The church sent missionaries to Asia and encouraged the expansion of universities.

The Great Schism. From 1378 to 1417, a controversy called the *Great Schism* deeply divided the church. During this period, two and later three churchmen claimed to be the rightful pope at the same time. Each man had his own following, his own College of Cardinals, and his own administrative organization. Each pope demanded obedience from the Christian faithful, which caused much confusion and doubt.

In 1417, bishops and other high-ranking clergymen meeting at the Council of Constance finally ended the Great Schism by electing Martin V as the single rightful pope. But the controversy had caused damage within the church. For example, reform efforts had been slowed. A conflict also had developed over the idea that a general council of bishops had greater authority than the pope. See Pope (The troubles of the papacy).

The close of the Middle Ages. From the 1300's through to the 1500's, medieval Europe gradually gave way to modern Europe. During these 300 years, the Middle Ages overlapped a period in European history called the *Renaissance.* This was a time of great cultural and intellectual activity when ideas and customs that had been accepted for hundreds of years were questioned or swept away. The Renaissance began in Italy in the 1300's and spread throughout Western Europe during the 1400's and 1500's.

The Renaissance emphasized the importance of people and their life on earth and had both good and bad effects on Catholicism. Popes supported Renaissance artists and scholars, but the papacy suffered a moral decline. The church sponsored important historical scholarship, but reform efforts within the church slackened.

Meanwhile, during the 1400's, a revival of deep religious feeling occurred among clergy and the laity. Many Catholics expressed this feeling in emotional *devotions* (prayers and worship) to the sufferings and death of Jesus. During this time, however, piety was being divorced from its roots in theology, and theology was hardening into schools of thought and losing much of its vitality.

The Council of Florence, which began in 1438, reunited the Western church with some Eastern churches. However, the reunification lasted only a few years. In 1453, Muslims captured Constantinople and ruled over most Eastern Christians until the 1800's.

The Reformation and Counter Reformation

Medieval Christian civilization ended with the *Reformation,* a religious revolution that gave birth to Protestantism in the 1500's. As a result of the Reformation, Europe became divided between Roman Catholic and Protestant countries. The Reformation also led the Catholic Church to reform itself in a movement called the *Counter Reformation.*

The Reformation. By the early 1500's, the conditions in the church that led to the Reformation were apparent. The papacy was dominated by temporal concerns. The Roman Curia was incredibly corrupt. Many bishops lived like princes and ignored the faithful. A great number of clergymen were ignorant and neglected their pastoral duties. Members of religious orders had become worldly. Fear and superstition were common among the laity. The liturgy no longer held much meaning or inspiration for the people, and theology had generally become dry and unproductive.

Many councils, popes, saints, scholars, and movements among the people had attempted to reform the church during the late Middle Ages. However, the church remained largely unreformed.

In 1517, Martin Luther, a member of the Augustinian order, issued his famous Ninety-Five Theses in Wittenberg, Germany. The theses were statements attacking the church's doctrine of indulgences and the abuses that arose in granting indulgences. An indulgence is a release from part or all of temporal punishment due for sin, provided that the sin has already been forgiven. The church's doctrine on indulgences was basically sound. But it was not always understood properly. Many preachers sold indulgences. Many people bought them from the church, hoping the indulgences would hasten the release of a dead person's soul from purgatory. Luther's attack on indulgences began the Reformation.

By the late 1500's, the Reformation had divided Western Europe into Protestant and Roman Catholic lands. Catholicism was reduced primarily to the Mediterranean countries, as well as to Hungary, Poland, and small areas within the Holy Roman Empire.

The Reformation in Great Britain. In England, Henry VIII declared himself head of the Church in England by the Act of Supremacy (1534). Within the next 25 years, England had become a Protestant nation. Mary I, a devout Roman Catholic, tried to reverse the process but failed. Under Elizabeth I, Roman Catholics who refused to attend new church services or recognize the Queen as head of the Church were persecuted. The persecution grew worse after 1570, when the Pope *excommunicated* Elizabeth (cut her off from the Roman Catholic Church). Roman Catholics in England lost their civil rights. Many were fined, imprisoned, or put to death. But some families retained their faith in secret.

In the later 1800's, such men as Cardinals Manning and Newman helped to re-establish Roman Catholicism as an important element in English life.

In Scotland, the Scottish Parliament rejected papal authority and abolished the Mass in 1560. In Scotland, as in England, Roman Catholics were suppressed. But many people, especially in the Highlands and Western Isles, retained their Catholic faith. Roman Catholics played a prominent part in the Jacobite risings of the 1700's.

In Ireland, the attempts of the English government to impose the Protestant religion on the people in the 1500's were largely unsuccessful. The government then encouraged Protestants from England and Scotland to settle in the province of Ulster. In the 1700's, the government enacted penal laws to suppress Roman Catholicism. In the early 1800's, Daniel O'Connell, Member of Parliament for Clare, led the struggle to gain religious and political rights for Roman Catholics. Largely as a result of his efforts, Roman Catholics in Britain and Ireland

received religious freedom in 1829. But conflicts between Catholics and Protestants in Ireland became part of the struggle over Irish nationalism.

There are now about $5\frac{1}{2}$ million Roman Catholics in Britain and more than 3 million in the Republic of Ireland. Roman Catholics believe that their Church is the same as the Christian Church established in Britain and Ireland in the A.D. 300's and 400's. See **United Kingdom, History of the** (Reformation).

The Counter Reformation was the Roman Catholic Church's self-reforming reaction to the Protestant Reformation. It is usually understood as extending from about the mid-1500's to the end of the Thirty Years' War (1618-1648). But indications of the church's move toward reform appear in the activities of three religious orders founded from 1524 to 1530—the Barnabites, Capuchins, and Theatines. Members of these orders tried to reform Catholic life through missionary and charitable work and by leading deeply religious lives.

Beginning in the 1520's, such reform popes as Adrian VI, Paul III, and especially Paul IV concentrated on correcting abuses in the Roman Curia and hierarchy. By the end of Saint Pius V's reign in 1572, the papacy had clearly committed itself to church reform.

A leading force in the Counter Reformation was the Society of Jesus, commonly called the Jesuits. Saint Ignatius Loyola founded the Jesuits in 1534, and Paul III confirmed the order in 1540. Loyola did not found the Jesuits specifically to counteract Protestantism. But the order proved perfect for the task. The Jesuits were flexible, practical, and completely at the pope's service. They were intelligent, deeply religious men who revived Catholicism both intellectually and spiritually. The Jesuits helped halt to a large extent the advances of Protestantism and even regained vast areas that had come under Protestant influence in Belgium, Luxembourg, the Netherlands, France, and eastern and central Europe.

Perhaps the greatest single force in renewing Catholic life and worship was the Council of Trent (1545-1563). The council issued decrees on the Mass and other areas of doctrine and discipline that eliminated much confusion within the church. Its decrees on such topics as the training of priests and the granting of indulgences reformed church life wherever they were put into effect.

A number of religious wars broke out during the Counter Reformation. Between 1562 and 1598, the Catholic majority in France and French Protestants called Huguenots fought eight civil wars called the *Wars of Religion.* The Thirty Years' War destroyed much of Germany. The war began as a civil war between Protestants and Catholics in the German states but eventually involved most European countries. The Peace of Westphalia, which ended the war in 1648, declared that the people of each state must follow the religion of their ruler. This principle greatly weakened the Holy Roman Empire. It also ended the medieval idea of a Christian commonwealth of nations directed by the supreme authority of pope and emperor. See **Counter Reformation.**

Catholic revival in France. Perhaps the most outstanding example of church renewal in the 1600's occurred in France. Several persons especially helped to create this renewal. Saint Francis de Sales, bishop of Geneva, inspired many Christians by his wedding of humanism and piety. Saint Vincent de Paul devoted his life to serving the poor. He founded the Vincentians, an order of missionary priests to country districts in France. Saint Louise de Marillac worked closely with Vincent de Paul in assisting the poor and needy. She was one of many saintly women who helped restore a sense of charity and deep religious feeling to both convent and Catholic family life.

During the 1600's, several French clergymen founded religious institutes that helped inspire a new emphasis on spirituality in the priesthood. Pierre Cardinal de Bérulle established the French Oratory in 1611. Jean Jacques Olier founded the Company of Saint Sulpice in 1642, and Saint John Eudes established the Congregation of Jesus and Mary in 1643.

The Revolt of the Catholic Kings

The period from the end of the Thirty Years' War in 1648 to the outbreak of the French Revolution (1789-1799) has been called the *Revolt of the Catholic Kings.* The period was marked by quarrels between church and state, especially over an issue called *Gallicanism.* At the same time, the church was disrupted from within by theological disputes, the most serious of which was over a religious movement known as *Jansenism.* During this period, much of the hostility toward the church centred in France.

Gallicanism. Quarrels between church and state affected the papacy's relations with almost every Catholic country. One of the major disputes involved *Gallicanism* —the idea that the authority of national churches should be increased at the expense of papal authority.

Gallicanism developed in France, and the dispute over it became most critical there. King Louis XIV and Pope Innocent XI quarrelled over Louis's attempts to increase his influence in French religious affairs. The quarrel led many French clergymen to adopt doctrines that the papacy could not in conscience accept. For example, some French clergymen believed that a general church council was superior to the pope. Although the controversy died down in the 1690's, the French clergy remained anti-Roman for many years.

Gallicanism, with its emphasis on nationalism, became popular in every European country ruled by a Catholic monarch. During the late 1700's, the Holy Roman emperor, Joseph II, tried to separate the Catholic Church in Austria from Rome. Joseph considered the church a department of state whose task was to promote morality. He controlled all levels of the clergy and even interfered with the liturgy. Rulers in Naples, Sardinia, Spain, and Venice followed Joseph's example.

Jansenism arose in France in the mid-1600's. This religious movement was based on the writings of Cornelius Jansen, bishop of Ypres, Belgium. Jansen developed doctrines on divine grace that played down human freedom and denied that Christ died for all humanity. The church attacked some Jansenist doctrines as heresy.

The movement tore Catholic France apart. It divided many French bishops from Rome and even attracted the attention of Kings Louis XIV and Louis XV. The Catholic philosopher and mathematician Blaise Pascal became a leading spokesman for Jansenism. Three popes condemned Jansenism—Innocent X in 1653, Alexander VII in 1656, and Clement XI in 1713. But their condemnation only increased the controversy.

Jansenism finally began to lose influence in the 1730's. But its harsh idea of God and emphasis on damnation still influence some Catholics today.

The Age of Reason was a period during which philosophers emphasized the use of reason as the best method of learning truth. The Age of Reason lasted from the late 1600's to the late 1700's. During this time, many people attacked religion in general and the Catholic Church in particular, which they claimed was unreasonable and filled with superstition. They also believed that the Catholic clergy's obedience to Rome violated France's sovereignty. The leaders of the period included such brilliant French intellectuals as Denis Diderot, Jean-Jacques Rousseau, and Voltaire.

Suppression of the Jesuits. During the mid- and late 1700's, several nations banned the Jesuit Order from their country and colonies. Portugal banned the Jesuits in 1759, France in 1764, and Spain in 1767. In 1773, pressure from Catholic rulers helped force Pope Clement XIV to suppress the Jesuits in all countries.

The Jesuits were banned for several reasons. Some Catholic rulers and churchmen were jealous of the order's influence. Some accused the Jesuits of accumulating power and wealth. Gallicans opposed the order's complete devotion to the pope and the church.

The suppression of the Jesuits was never completely effective. For example, the order survived in Russia through the friendship of Empress Catherine the Great. Pope Pius VII lifted the ban in 1814. But the suppression caused a severe setback in Catholic education and missionary activity.

Nationalism and the church

The forces of democracy and nationalism swept across Europe from the start of the French Revolution through the 1800's. These forces were accompanied by strong feelings against the Catholic Church.

The decline of church influence. The church suffered enormous losses as a result of the French Revolution. For example, the great abbeys of Europe disappeared, and with them the influence of the monastic orders as the papacy's most effective instrument of government. Catholic influence over public life was seriously reduced, often by civil laws. Catholic universities yielded to state-sponsored education. The quality of theology came to be determined by seminaries rather than by universities. In many countries, the church suffered from a shortage of priests. This was especially true in France. During the French Revolution, the church lost half its clergy. Many priests were executed or died in prison. Others left the church.

The papacy had governed certain Italian and French territories called the *Papal States.* These territories were gradually absorbed by secular states. By 1870, the papacy had lost the last of its land. The pope's territory was reduced to Vatican City.

Although the church suffered setbacks and hostility during the 1800's, Catholic life itself experienced renewal. The restoration of the Jesuit Order in 1814 enabled it to play a large role in that renewal. New religious orders of women became active in education in Belgium, France, and Germany. In Germany, the Congress of Mainz founded the Catholic Union in 1848. The union was an association of Catholics dedicated to promoting the ideals of their religion in social life.

Vatican Council I. In 1846, Pius IX became pope. He ruled until 1878—the longest reign in papal history. Pius' reign reached a high point when he summoned Vatican Council I (1869-1870). The council defined as Catholic doctrine the pope's primacy over the whole church. It also declared him to be *infallible*—that is, incapable of error when, as supreme head of the church, he formally defines matters of faith and morals.

Leo XIII. A new age of church history began after Leo XIII became pope in 1878. Leo tried to convince liberal governments that they and the church could live in harmony. He faced especially strong antichurch feeling in Germany, France, and Italy.

In Germany, Leo succeeded in easing the liberal government's restrictions against the church. But he failed in France and Italy. In fact, the French government passed new antichurch laws in 1880. These laws expelled religious orders from France, banned religious education in the schools, and excluded the church from several other areas of French life. In Italy, hostility toward the church came from the people as well as the government. This hostility led to antipapal—and anti-Christian—laws and demonstrations.

Leo began a new policy of maintaining contact between the papacy and everyday Catholic life. He established this contact through letters to the Catholic world. The letters dealt with such subjects as philosophy and Bible studies, theology and church law, and the relations between the state and the working class. Leo's most important statement on social questions was called *Rerum Novarum* (1891).

The church around the world

While the church lost much ground in Europe to Protestantism, it achieved enormous success in the New World. From the early 1500's to the late 1700's, Catholic missionaries carried the faith throughout the Western Hemisphere, in connection with the colonizing efforts of Spain, France, and England. The Spanish missions covered much of Latin America and an immense territory across the southern United States. Spanish influence was also strong in the Philippines.

In Asia. Catholic missionaries were sent to every country that European colonial interests discovered in the 1500's. They were most sucessful where Spanish control was strong. In the Philippines Muslim opposition was overcome by 1574 and the majority of the Philippine population became Roman Catholic. Missionaries who reached Japan in 1549 established a Roman Catholic following in Kyushu. But later Japanese rulers turned away from Western influence and in 1637 Japanese Catholics were forced to give up their faith. It was not until 1873 that religious freedom was granted once more. A small group of secret Christians had survived in spite of the persecution and the church now has a large following in southern Japan. In India the missionary Saint Francis Xavier established the church in Goa in 1544. Goa was then a Portuguese colony. Today, the largest Indian Roman Catholic community is in Goa.

In Latin America. Soon after Christopher Columbus arrived in the New World in 1492, Spain and Portugal claimed nearly all Latin America. Catholic missionaries accompanied Spanish and Portuguese explorers and

colonists and converted most Latin American Indians.

Many natives accepted Christianity only under pressure from colonial rulers and, in fact, still retained their old religious beliefs. As a result, the church tried to strengthen the faith of the converts. For example, it helped establish universities in Lima, Peru; Mexico City; and elsewhere. The church also recruited clergy from among Latin Americans. But the quality and quantity of native-born priests proved inadequate for church needs. Catholicism in Latin America thus remained almost totally dependent on the church in Europe.

The Latin American church declined during the 1800's, after many colonies gained their independence from Spain and Portugal. The church had had close ties with the colonial powers, and many clergymen had opposed the independence movements. As a result, many Latin Americans became hostile toward the church.

Today, there is a renewal of Catholicism in Latin America, mainly because bishops and priests have become involved in social problems. Following a movement called *liberation theology,* they established *base communities* (local Christian groups) that study the Bible together and try to help provide their people's need for basic amenities. These communities are led by lay people, but many priests have been criticized for their part in this movement and accused of supporting violent social revolution. Also, Protestantism has won many people away from Catholicism, and anticlerical feelings remain strong in many countries.

In the United States. The mainstream of American Catholic life emerged from the minority Catholics of the English colonies rather than from the state-favoured Catholics of the French and Spanish colonies. Occasionally, the governments of the English colonies passed anti-Catholic legislation. But, in general, they followed a policy of religious freedom. This freedom and the growing separation of church and state helped make the Catholic Church acceptable to non-Catholics.

American bishops coordinated their various activities by forming and reforming themselves into a national conference in 1917, 1919, 1922, and 1966. Immigration restrictions passed by Congress in the early 1920's led to a relatively stable native Catholicism. The American church attacked most social issues with courage and intelligence. However, the church did not begin to deal with the problem of discrimination against black people until the 1940's.

The number of American missionaries in other lands leaped from 14 in 1906 to about 6,000 in the late 1980's. Catholic education, from primary to university level, spread throughout the country. Catholics became a powerful political factor, especially in large cities. The election of John F. Kennedy, a Catholic, as president in 1960 symbolized the assimilation of the church into American society.

The church today

The reign of Saint Pius X, which lasted from 1903 to 1914, featured the most impressive reform activity since the Council of Trent in the 1500's. Reforms were made in such areas as liturgy, Holy Communion, seminary education, Biblical studies, and church law. Pius also vigorously opposed *Modernism,* a movement that began in the late 1800's among Catholics in several European countries. In their desire to bring Catholic belief into closer relation to the knowledge and outlook of the time, Modernists came into conflict with many important Catholic teachings on such important matters as the Bible and dogma. Modernism died out by about 1910, largely because of Pius's condemnation.

During the 1920's and 1930's, the church made *concordats* (agreements) with many nations to guarantee its freedom and its spiritual authority over Catholics in the countries involved. During this period, the church also updated its worldwide missionary activities.

Throughout the 1900's, the church has faced hostility from European dictatorships. During the 1920's and 1930's, dictatorships in Germany, Italy, and the former Soviet Union often opposed the church. After World War II (1939-1945), the church faced severe antireligious pressure in the Communist countries of Eastern Europe. In the 1940's and 1950's, Pope Pius XII worked constantly to preserve the religious freedom of Catholics living under dictatorships. In the early 1990's, the collapse of Communism brought the church in Eastern Europe greater religious freedom.

John XXIII succeeded Pius in 1958. A turning point in church history came when John called Vatican Council II (1962-1965). The council issued 16 documents that tried to give a deeper understanding of the church and its doctrine and help the church serve the needs of the modern world. The council also involved the church more fully in the *ecumenical movement* to unite all Christians. The council's efforts to renew and reform the church have brought joy and inspiration to many Catholics, but also have been a continuing source of controversy within the church. See **Vatican Council.**

In 1983, Pope John Paul II issued a new code of church law that reflected many of the changes begun by Vatican Council II. For example, the new code increased the role of the laity in parish and diocesan advisory bodies. In 1993, the pope issued a strong *encyclical* (papal message), considered to be one of his most far-reaching statements. In it, he reaffirmed the church's conservative stance on issues such as homosexuality and birth control. In the same year, the Vatican signed an agreement with Israel establishing diplomatic relations. This formal recognition between the Roman Catholic and Jewish states put an end to a long history of hostility and mistrust.

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See the separate articles **Pope,** with its table: The popes; **Cardinal,** with its tables; and **Saint,** and its list of *Related articles.* See also:

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Bossuet, Jacques B.	Mathew, Theobald
Campion, Edmund	Merton, Thomas
Chichele, Henry	Peter the Hermit
Colet, John	Pole, Reginald
Damien de Veuster, Joseph	Savonarola, Girolamo
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Doctrines, beliefs, and ceremonies

Advent
Angelus
Annunciation
Anointing of the sick
Apostles' Creed
Baptism
Bible
Canonization
Communion
Confirmation
Excommunication
Feasts and festivals
Immaculate Conception
Indulgence
Lent
Limbo
Liturgy
Mass
Pentecost
Purgatory
Rosary
Sacrament
Transubstantiation
Trinity

Hierarchy

Abbot
Archbishop
Bishop
Cardinal
Friar
Metropolitan
Monastery
Monk
Nun
Patriarch
Pope
Priest

History

Counter Reformation
Freedom of religion
Inquisition
Lateran
Middle Ages
Missionary
Nicene Councils
Papal States
Pisa, Council of
Popish Plot
Reformation
Renaissance
Scholasticism
Trent, Council of
Vatican City
Vatican Council

Religious institutes

For a list of articles on religious institutes, see the *Related articles* at the end of the **Religious life** article.

Other related articles

Birth control
Bull
Christianity
Divorce
Encyclical
Fátima
Index Librorum Prohibitorum
Jesus Christ
Lourdes
Old Catholic churches

Outline

I. Roman Catholic beliefs
A. The Trinity and creation
B. Sin and salvation
C. The nature of the church
D. Life after death
E. Catholic morality

II. Worship and liturgy
A. The Eucharist, or Mass
B. The seven sacraments
C. Sacramentals

III. Church organization
A. The church's functions
B. The role of the clergy
C. The role of the laity

IV. Church government
A. The pope
B. The Roman Curia
C. Bishops
D. Dioceses and parishes
E. Religious institutes

V. The early church
A. The first 300 years
B. The recognition of Christianity
C. Conflict with the East

VI. The Middle Ages
A. The papacy
B. Monasticism
C. Charlemagne
D. Cluniac reform
E. Split with the East
F. Innocent III
G. Scholasticism
H. Boniface VIII
I. The Avignon papacy
J. The Great Schism
K. The close of the Middle Ages

VII. The Reformation and Counter Reformation
A. The Reformation
B. The Reformation in Great Britain
C. The Counter Reformation
D. Catholic revival in France

VIII. The Revolt of the Catholic Kings
A. Gallicanism
B. Jansenism
C. The Age of Reason
D. Suppression of the Jesuits

IX. Nationalism and the church
A. The decline of church influence
B. Vatican Council I
C. Leo XIII

X. The church around the world
A. In Asia
B. In Latin America
C. In the United States

XI. The church today

Questions

What is an *indulgence?*
How did Cluniac reform influence the medieval church?
What is the Roman Curia?
What is *Gallicanism? Modernism?*
How do the sacraments differ from sacramentals?
Why did the Eastern and Western churches split?
What are religious institutes?
What was the *Great Schism?*
What is *purgatory?*
How did the French Revolution affect the church?

Roman Circus. See Rome, Ancient (Recreation).
Roman Empire. See Rome, Ancient.
Roman Forum. See Forum, Roman.
Roman gods. See Mythology.

Vatican Council II was the most influential event in the modern history of the Catholic Church. From 1962 to 1965, church leaders met in Rome, where they established far-reaching reforms in many areas of church life. The council also proclaimed the church's new, liberal position in its relations with non-Catholics.

Roman law. See Law (Ancient Roman law); **Justinian I**; Rome, Ancient (The law).

Roman mythology. See Mythology.

Roman numerals are symbols that stand for numbers. All Roman numerals are written using seven basic symbols, either alone or in combination. These seven symbols are I (1), V (5), X (10), L (50), C (100), D (500), and M (1,000).

Roman numerals are written from left to right, using the principle of addition in most cases. A person first writes the thousands, then the hundreds, then the tens, and finally the units. To write 2,763, first write MM (2,000), then DCC (500+200=700), next LX (50+10=60), then III (3). The number 2,763 appears as MMDCCLXIII. A bar is sometimes placed over a Roman numeral to multiply it by 1,000. For example, 5,000 appears as $\overline{\text{V}}$.

In Roman numerals, a smaller numeral appearing before a larger numeral indicates that the smaller numeral is subtracted from the larger one. This principle is generally used for 4's and 9's. Thus, 4 usually appears as IV (5 minus 1), and 9 usually appears as IX (10 minus 1). The principle is usually applied to any number beginning with 4 or 9, such as 40 (XL) and 90 (XC). However, the principle of addition can also be used in writing such numbers. For example, 400 can be written as CCCC instead of CD.

The ancient Romans invented Roman numerals. But the early Roman system of about 500 B.C. differed from the system people commonly use today. For example, the Romans always wrote 4 as IIII and 9 as VIIII. In addition, they had different symbols for numbers that can be divided by 1,000.

People throughout Europe used Roman numerals until the A.D. 1500's. They found it easy to add and subtract using Roman numerals but difficult to perform other calculations. In the late 1500's, people began using Arabic numerals instead. Today, the Roman system is used to number the faces of clocks, and to record dates on monuments and public buildings.

See also **Arabic numerals**; **Numeration systems** (History).

Roman numerals from 1 to 1,000,000

1	I	50	L
2	II	60	LX
3	III	70	LXX
4	IIII or IV	80	LXXX
5	V	90	LXXXX or XC
6	VI	100	C
7	VII	200	CC
8	VIII	300	CCC
9	VIIII or IX	400	CCCC or CD
10	X	500	D
11	XI	600	DC
12	XII	700	DCC
13	XIII	800	DCCC
14	XIIII or XIV	900	DCCCC or CM
15	XV	1,000	M
16	XVI	2,000	MM
17	XVII	3,000	MMM
18	XVIII	4,000	MMMM or M$\overline{\text{V}}$
19	XVIIII or XIX or IXX	5,000	$\overline{\text{V}}$
20	XX	10,000	$\overline{\text{X}}$
30	XXX	25,000	$\overline{\text{XXV}}$
40	XXXX or XL	50,000	$\overline{\text{L}}$
		100,000	$\overline{\text{C}}$
		500,000	$\overline{\text{D}}$
		1,000,000	$\overline{\text{M}}$

Roman Republic. See Rome, Ancient (Government; History).

Roman Roads. The Romans were the greatest roadbuilders in ancient times. They produced a system of roads that provided a transportation network spanning the whole of the Roman Empire. The network stretched from Britain in the west to the banks of the Tigris and Euphrates Rivers in the east. To the north, the roads reached the River Danube and to the south they went as far as Spain. Romans also built roads in North Africa.

Most of the roads were constructed for military purposes, enabling soldiers to move quickly. This made the conquest and rule of Roman provinces easier. But the system of Roman roads also made it possible for ordinary travellers, particularly traders and merchants, to move about freely and transport their goods easily.

Roman roads were remarkable for their straightness. The roads generally went over hills rather than around them. They were also noted for the solidity of their foundations. In making the roads, Roman engineers used a form of concrete made from volcanic ash and lime. For general information on the construction of Roman roads, see **Road.**

A Roman official named Appius Claudius Caecus ordered the building of the first Roman road in Italy in 312 B.C. This was the *Via Appia* (the Appian Way), which ran southeast from the city of Rome. It originally connected Rome to Tarentum (now Taranto), a distance of about 250 kilometres. It was later extended as far as the Adriatic coastline. In the next 100 years, the Romans built the Via Aurelia, the Via Flaminia, the Via Valeria, and the Via Latina, all radiating from Rome. Other roads branched off these main highways. In time a road network developed, centred on the empire's capital city and connecting it with its provinces. This fact gave rise to a proverb we still hear today, that "All roads lead to Rome".

Other road systems evolved elsewhere in the empire. For instance, in Gaul (France), Lyon, the provincial capital, was the hub of a road network that extended northeast to the River Rhine, northwest to the English Channel, and west to Bordeaux. London became the hub of a series of radiating roads.

In Britain, the Romans made London their headquarters following the invasion of A.D. 43. From there they advanced north and west, building roads as they went.

Watling Street was perhaps the earliest Roman road in Britain. It ran from Dover and Richborough, in Kent, right across England to Chester, in Cheshire. The modern A2 and A5 roads follow part of the same route. Watling Street passed through London and major walled towns such as St Albans and Wroxeter.

Ermine Street connected the great administrative centres of London and York. It was laid out in long, straight stretches through the walled towns of Godmanchester and Water Newton in Cambridgeshire, and Lincoln (where a Roman arch still spans it) to Wintringham on the River Humber. A ferry connected Wintringham to Brough, from where Ermine Street carried on to York. The Great North Road (A1) follows the same route for much of the way.

North of York, Ermine Street is called *Dere Street*. It was the main supply line to the frontier armies. It passed through the walled towns of Aldborough and Catterick, in North Yorkshire, and then entered the military zone.

Dere Street had forts at regular intervals along it as far as Corbridge, in Northumberland, the great depot for the frontier.

Akeman and Ermin streets were alternative routes westwards from London to Gloucester and the army posts in southern Wales. *Ermin Street,* the southern and more important road, ran in long, straight stretches through the walled towns of Silchester, in Hampshire, Cirencester, and Gloucester. It is particularly well preserved in the Cirencester region. *Akeman Street* began west of St. Albans and ran through smaller settlements, including Alchester, joining Ermin Street at Cirencester.

The Fosse Way ran from Lincoln through the walled towns of Leicester, Cirencester, and Bath, to a point near Axminster. It was built as a military frontier road but also served as a cross-country route. Today, it survives in tracks and farm roads. It is well preserved near Bourton-on-the-Water.

Stane Street ran in an almost straight line from London to Chichester. It changed direction only on the steeper slopes of the North and South Downs. The present-day A29 follows part of its route. Stane Street is well preserved northeast of Chichester.

The London-Colchester Road is followed by the present-day A12 for most of its length. Near Colchester, it had three traffic lanes. North of Colchester, a smaller road, the *Pye Road,* led through unwalled settlements to Caistor St. Edmund, in Norfolk.

The Military Way ran along the Turf, or Antonine, Wall, which stretched from the Firth of Clyde to the Firth of Forth. It was a purely military road, linking the 20 forts along the wall. It was cleverly laid out to avoid the most difficult slopes.

The excellence of the Roman road system was a major factor in holding the empire together. But it also helped its destruction. When migrating tribes ranged the Roman empire in the A.D. 200's, 300's, and 400's they were able to use the fine roads to travel about easily.

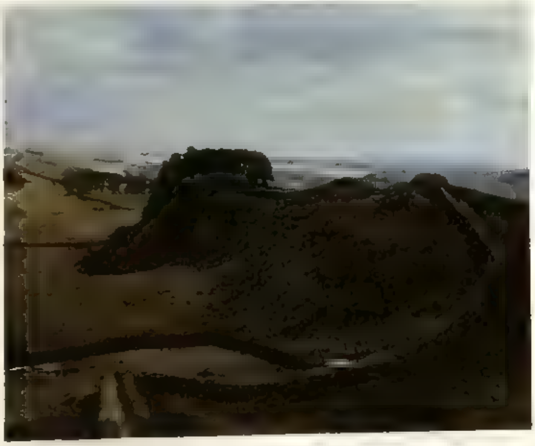
For a map of Roman roads in Britain, see **United Kingdom, History of the** (Roman Britain [55 B.C.-A.D. 410]).

Roman walls were barriers that the Romans built where no natural territorial boundaries existed. By A.D. 100, they had built a line of walls in what is now Romania and Germany. They later built Hadrian's Wall and the Antonine Wall along the northern edge of the province of Britain. These walls were named after two Roman emperors, Hadrian and Antoninus Pius, and are the most famous Roman walls.

The walls discouraged raids and revolts. But their main purpose was to remind the tribes on both sides that the Romans were masters. The walls also made it easier for the Romans to control trade and to collect taxes.

Hadrian's Wall was built in the A.D. 120's. It extended 117 kilometres, from the mouth of the Tyne River to the Solway Firth. Parts of the wall are still standing. It was about 3 metres wide at its base and 6 metres high. For half its length, it was made entirely of stone. The rest was stone and turf. Forts stood about 1.6 kilometres apart along the wall, with small watch towers every 0.5 kilometre. A ditch lay in front of the wall, with a wider ditch 3 metres deep behind it. One of the best-known forts is at Housteads near Hexham, Northumberland, in the United Kingdom. Archaeologists have uncovered a civil settlement, called *Vindolanda,* which was built around the fort.

Stone walls surround the ruins of ancient Pevensey Castle in Sussex, England. The walls date from about A.D. 250. This Roman fortress was built on what was once a group of small islands off the shore. The sea receded hundreds of years ago.



Emperor Hadrian's wall, built across northern England in the A.D. 120's, consisted of fortified sites joined together by a great wall. The ruins in some places are still 1.5 to 1.8 metres high and wide enough to walk on.

The Antonine Wall was built in the A.D. 140's, north of Hadrian's Wall. It was a simpler wall, made of turf, and it stretched for 60 kilometres.

The Romans allowed Hadrian's Wall to decay until 211, when they could no longer defend the Antonine Wall against raids by the Picts from what is now southern Scotland. Then they rebuilt Hadrian's Wall carefully. They rebuilt it twice more in the 300's, and defended it until nearly 400.

Romance is a long work of fiction that is less realistic than a novel. Most novelists try to present life realistically. Writers of romance concentrate on telling an entertaining story. Many use fantastic and supernatural plots and characters.

Some romances deal with philosophical or social issues. They may use *allegory* (a story with a double meaning) to disguise their deeper purpose. Great allegorical romances include *Moby-Dick* (1851), by the American author Herman Melville. On one level, *Moby-Dick* is a fascinating adventure story about whaling. On a deeper level, it explores the human struggle against the mysterious force of the universe.

The meaning of the term *romance* has changed many times since the first romances appeared in Greece almost 2,000 years ago. In ancient Greek literature, most fiction dealt with either love or war. War stories were called epics, and love stories were called romances. The word *romance* is still used for a love story. By about the 1200's, most Western Europeans spoke either Latin or a Romance language, such as French, Italian, or Spanish. All fiction written in Romance languages was called romance. In most Romance languages today, the word for *romance* refers to all long prose fiction. The word for *novel* means all short prose fiction. English is the only language in which the words *novel* and *romance* distinguish between realistic and unrealistic fiction.

The first important romance was *Daphnis and Chloë,* (A.D. 100's or 200's) by a Greek named Longus. The greatest romances were written by medieval authors from the 1100's to the 1400's. The most famous medieval romances describe the adventures of King Arthur and his knights of the Round Table. Others tell about the ancient conqueror Alexander the Great; the Spanish hero The Cid; and the emperor Charlemagne and his devoted knight, Roland.

The romance flourished again during the late 1700's and 1800's. In England, Horace Walpole's *The Castle of Otranto* (1764) began a trend for romances that emphasized mystery, terror, and the supernatural. These romances became known as *Gothic novels.*

See also **Round Table.**

Romance languages are a group of languages that developed from Latin and are spoken in places that were once part of the Roman Empire. They include French, Italian, Portuguese, Romanian, and Spanish. Other Romance languages are Catalan of northeastern Spain and Provençal of southeastern France. The group also includes the Sardinian dialect and Rhaeto-Romanic dialects from certain parts of Switzerland and the Tyrol region of western Austria and northern Italy.

Latin was the official language of the Roman Empire. The word *romance* comes from a Latin adverb that referred to speakers of Latin who were said to "fabulare romanice," which means "to speak in the Roman way." These people spoke one of two forms—*classical* Latin or *vernacular* Latin. The educated classes spoke classical Latin. The common people spoke vernacular Latin. Romance languages developed from vernacular Latin spoken in certain conquered European countries that became Roman provinces. This vernacular Latin adopted words and features of pronunciation from the languages of the conquered countries. For example, the vernacular Latin word *caballus* (horse) became *cheval* in French, *cavallo* in Italian, and *caballo* in Spanish.

The Romance languages developed from the many dialects of vernacular Latin over several centuries. The earliest evidence of Romance languages appeared in the 800's. By the late 1200's, much literature was written in the Romance languages. So many literary works centred on the topic of love that they became known as *romances.* The word *romance* meaning *an affair of the heart* comes from this usage.

Related articles in *World Book* include:

French language	Portuguese language
Italian language	Romance
Latin language	Spanish language

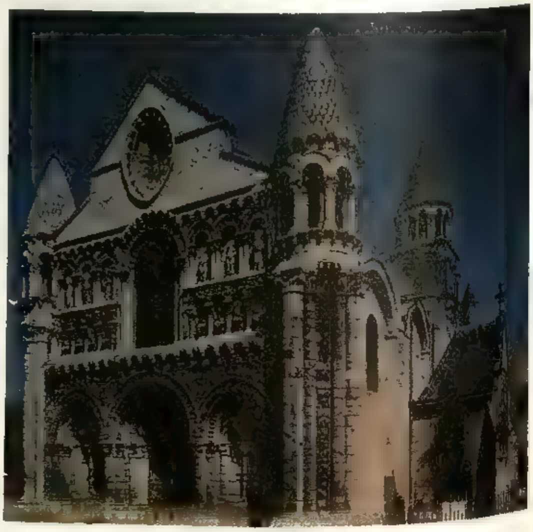
Romanesque architecture was the prevailing architectural movement in western Europe from about A.D. 800 to the 1100's. Romanesque architecture developed into a number of regional styles, including Aquitaine, Brittany, Burgundy, Île-de-France, Norman, and Provence. Romanesque buildings were frequently isolated from the few developed cities of the period. Their massive character was a response to the demands for security and defence that such locations required.

The Romanesque style was especially well developed in churches and monastic structures. The plan of a typical Romanesque church was in the shape of a *Latin cross*—that is, a cross with a vertical arm and a shorter horizontal crosspiece above the centre. The roof over the *nave* (main gathering area) consisted of vaults of stone constructed on the principle of the arch. Side aisles flanked the nave. Large columns called *piers* supported the roof vaults. Round arches were built in openings in the walls and between the piers. The openings and piers were decorated with stone sculpture and carvings depicting Biblical scenes and people (see **Sculpture** [picture: The prophet Isaiah]). Walls were painted in fresco and also portrayed religious subjects.

By the mid-1100's, the Romanesque style had evolved into Gothic architecture. The chief reasons for the evolution included less need for defensive buildings and a desire for lighter and higher churches.

See also **Architecture** (Romanesque architecture; pictures); **Norman architecture; Leaning Tower of Pisa.**

Romanesque painting. See Painting (Romanesque painting).



A typical Romanesque church had thick walls and heavy curved arches. Notre-Dame-la-Grande (1130-1145) in Poitiers, France, is noted for its richly decorated west front.

Farm villages are scattered throughout the Romanian countryside. Rich farmland covers about 60 per cent of Romania, and about half the nation's people live in rural areas.

Romania

Romania, also spelled *Rumania,* is a country in eastern Europe. Its name means *land of the Romans.* The country is so called because it was part of the Roman Empire during ancient times. The Romanian people are the only eastern Europeans who trace their ancestry and language back to the Romans. Bucharest is Romania's capital and largest city.

Romania lies west of the Black Sea and north of the Balkan Peninsula, Europe's southeastern tip. A long string of mountains curves through northern and central Romania. Breathtaking scenery, hiking trails, and ski and holiday resorts make the mountains a favourite recreation area. Picturesque farm villages dot fertile flatlands around the mountains. Romania's warm, sunny east coast—which borders the Black Sea—has dozens of sandy beaches and a huge wildlife preserve.

The colourful folk culture of Romania's rural people adds to the beauty and charm of the country. Each year, these people hold festivals at which they dance to the lively sounds of Romanian folk music. This music was influenced by the melodies of Gypsies, nomads who once wandered through Romania by the thousands.

Romania has a wealth of natural resources, including fertile soil, mineral deposits, and vast forests. Even so, it has always been one of Europe's least developed nations. Foreign nations controlled the country through much of its history and did little to develop its economy. Romania also suffered from an overdependence on one economic activity, agriculture.

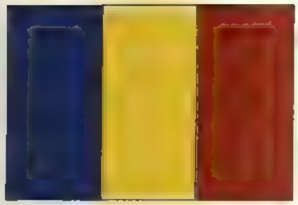
Communists took over Romania's government in the 1940's. At first, they ran the country according to the wishes of the Soviet Union, which was Europe's strongest Communist nation. But beginning in the 1960's, Romania's Communists succeeded in reducing Soviet control, and they adopted their own domestic policies. Chief among these policies was a programme to expand industry. This programme changed Romania from an agricultural to an industrial country. But the country remains poor by European standards.

In the late 1980's, the Soviet Union made reforms toward giving its people more freedom. Reform movements then increased in Romania and other European Communist countries. In late 1989, Romanians revolted against the dictatorship of Nicolae Ceausescu, Romania's president and Communist Party leader. After a secret trial, Ceausescu was executed, and a temporary government was set up. Free multiparty elections have been held since 1990.

Facts in brief about Romania

Capital: Bucharest.
Official language: Romanian.
Official name: Republica România (Republic of Romania).
Area: 237,500 km². *Greatest distances*—east-west, about 724 km; north-south, about 515 km. *Coastline*—209 km.
Elevation: *Highest*—Mount Moldoveanu, 2,543 m above sea level. *Lowest*—sea level.
Population: *Estimated 1996 population*—23,611,000; density, 100 people per km²; distribution, 53 per cent urban, 47 per cent rural. *1992 census*—22,760,449. *Estimated 2001 population*—24,152,000.
Chief products: *Agriculture*—maize, potatoes, wheat, milk, sugar beet, grapes, wool. *Manufacturing*—machinery, cement, iron and steel, petroleum products, processed foods, clothing and shoes, wood products. *Mining*—petroleum, natural gas, coal.
National anthem: "Desteapta-te Române" ("Romanian, Arise").
Money: *Currency unit*—leu (plural lei). One leu = 100 bani.

The Palace of the Republic in Bucharest, the capital of Romania, is part of a complex of government buildings. It houses government offices and an art museum.



Symbols of Romania. Romania's flag has stripes of blue, yellow, and red. The three stripes represent Romania's national colours. The eagle on Romania's coat of arms, *right,* is a symbol of the region of Walachia. The other symbols on the coat of arms represent each of Romania's five other regions.

Government

The Communist Party became Romania's ruling political party in the 1940's. It exerted its power over the country's entire governmental structure. Only a small percentage of Romania's people belonged to the party. However, Communist Party leaders held important positions at all levels of government and in major nongovernmental organizations. The general secretary, who was also the head of the Communist Party, had the authority of a dictator.

The Communist Party leaders made the country's laws and planned every detail of its economy. They also controlled Romania's police and armed forces. The country's Constitution guaranteed such rights as freedom of speech, the press, and religion.

But in practice, the Communist government interpreted the Constitution to mean that they could limit these rights in order to maintain power.

In December 1989, Romanians revolted and overthrew their government. Free multiparty elections to select a president and members of a national legislature have been held since mid-1990. The election held in 1992 was won by the Democratic National Salvation Front, a party that had broken away the same year from the former majority party, the National Salvation Front.

National government. Romania's top government official is the president, who is elected by the people. The president appoints a prime minister, who selects a Cabinet to help carry out the operations of government. The Romanian people elect a 484-member two-house legislature. It consists of the 143-member Senate and the 341-member Chamber of Deputies.

Political parties. Romania has about 80 political parties. The largest of these parties is the Democratic National Salvation Front. Other political parties include the National Salvation Front, the National Peasant Party, Christian Democrat, the Romanian National Unity Party, the Hungarian Democratic Union, and the Romania Mare Party.

Local government. Romania is divided into 40 counties and 1 special district, the city of Bucharest. Each unit has its own local government, as do cities, towns, and *communes* (rural areas) within the counties.

Courts. The Supreme Court is Romania's highest court. It hears appeals from lower courts. The city of Bucharest and each of Romania's 40 counties have a county court and a variety of lower courts.

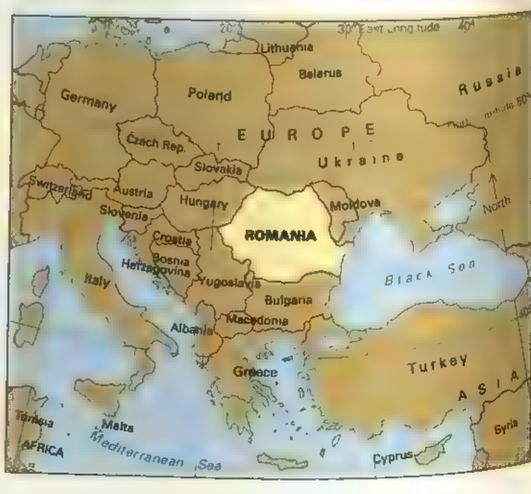
Armed forces. Romania's regular army, navy, and air force have a total of about 180,000 men. Men 18 years old may be conscripted, usually for 16 months.

People

Ancestry and population. For Romania's total population, see the *Facts in brief* table with this article. More than 85 per cent of its people are Romanians by ancestry. The Romanians are descended from the Dacians, Romans, and such tribes as the Goths, Huns, and Slavs. The Dacians lived in what is now Romania as early as the 300's B.C. The Romans occupied the country in the A.D. 100's and 200's, and the tribes began living there in the late 200's, following a series of invasions over the course of several hundreds of years.

Hungarians form the largest minority group in Romania, making up about 8 per cent of the population. Germans make up about 2 per cent. Smaller groups include Gypsies, Jews, Turks, and Ukrainians.

About half of Romania's people still live in rural areas. Each year, however, many rural Romanians move to cities to take jobs in industry. Bucharest is Romania's largest city by far. It has about 2 million people.



Romania is in eastern Europe and has a coastline on the Black Sea. Ukraine and Moldova border it on the north and east.

Language. Romanian is the nation's official language and is spoken by almost all the people. Many of Romania's Germans and Hungarians prefer to speak their own ethnic languages among themselves.

Romanian developed from Latin, the language of the Romans who ruled the country in ancient times. Romanian is the only Eastern European language that comes from Latin. As a result, it is much different from all the other languages that are spoken in the region. Romanian most closely resembles French, Italian, Portuguese, and Spanish. These Western European languages also developed from Latin.

Way of life. The Romanian people have one of the lowest living standards in Europe. Almost all of the workers in Romania earn enough to pay for their families' food, clothing, and shelter, and have a little left over for recreation. But few Romanians can afford many luxury items. For example, only about 15 per cent of the people own a television set, and about 1 per cent own a car.

Most rural Romanians live in two- or three-room wooden cottages. The houses are plain and simple, but many people beautify them with a variety of art objects that they make themselves. These objects include wall rugs with skilfully-woven patterns, colourfully decorated plates, and wood carvings on furniture, building frames, and fences.

Festivals held to celebrate such things as weddings, christenings, and holidays are the most important part of social life in rural Romania. At the festivals, the people wear colourful costumes and play, and dance to, Romanian folk music.

Romania's cities present a striking contrast between the old and the new. Many city buildings are hundreds of years old. Others are modern structures built since industrialization began in the 1960's. Population growth has caused a housing shortage in the cities. Most city people live in crowded apartments.

Bucharest is Romania's capital and largest city. Many parts of the city have wide boulevards and modern buildings constructed since the 1960's. Other sections are centuries old.

Crowds of holiday makers enjoy the sandy beaches and sunny weather along Romania's Black Sea coast. Fashionable resort hotels line the streets in this popular recreation area.

Both old Romanian traditions and modern, Western culture are part of city life. Many people enjoy going to restaurants and to concert halls where orchestras play Romanian folk music. They also visit exhibits of rural Romanian folk art that the government sets up in cities. But many people—especially the young—like rock music and Western films, plays, and books.

Before the 1989 revolt, the lives of the Romanian people were affected by the Communist government in many ways. The government decided what kind of jobs students should prepare for in school. It owned or managed most of the country's businesses and farms, and so almost all the people worked for the government. Romanians could not change their jobs or leave the country without the government's permission. After the revolution, the non-Communist government lifted most of these restrictions.

Recreation. Romanians have two favourite vacation spots—the mountains and the Black Sea coast. The mountains offer skiing, hiking, mountain climbing, and beautiful scenery. Romanians go to the Black Sea coast to swim and to relax in the sun. Soccer is the most popular spectator sport in Romania.

Food and drink. Romanians enjoy grilled meats, including *mititei* (meat balls shaped like cylinders) and *patricieni* (sausages). Another favourite food in Romania is *mamaliga,* a bread or mush made from corn meal, which can be cooked and served in many ways. Wine and a plum brandy called *tzuica* are popular drinks in Romania.

Education. Romanian law requires children from 6 to 16 to attend school. Primary school lasts eight years. Students then take tests that are prepared by the government to determine what kind of course they will study in

Colourful festivals are held by rural Romanians to celebrate holidays, weddings, and other occasions. Bright costumes and lively folk dances are traditional features of such celebrations.

secondary school. About half the students are assigned to vocational courses. These students learn the basic skills that are needed for work on farms or in factories. Most of the other students take courses that train them in advanced technical skills, in the arts, or in teaching. The top primary school graduates—about 5 per cent of the total—are assigned to courses that prepare them for college.

Romania has seven universities. The largest Romanian university is in Bucharest.

Religion. About three-fourths of all Romanians belong to the Romanian Orthodox Church, an Eastern Orthodox Church. About 7 per cent of the people—chiefly Hungarians—are Roman Catholics. Other faiths that are practised in Romania include Islam, Judaism, and various forms of Protestantism. In order to avoid popular protests, the prerevolution Communists allowed churches to operate as long as the churches avoided political activities. After the revolution, the churches were granted complete religious freedom.

Arts. Romania's rural culture has had a strong influence on the country's professional art. The lives and customs of rural Romanians have long been favourite topics of Romanian writers. The works of many composers show the influence of Romanian folk music. The best-known Romanian paintings are medieval works that appear on the outside walls of churches. These works were done outside, rather than inside, to remind peasants passing by of their faith.

In the 1950's, the government forced Romanian artists to use their works to promote Communism. Romanian art grew dull from a lack of self-expression. However, since the 1960's, the government has allowed artists more freedom and art has flourished in Romania. Old Romanian themes and styles are still popular. But many artists have turned to modern styles, and deal with such themes as humanity's relation to the universe.

The composer Georges Enesco, the sculptor Constantin Brancusi, and the playwright Eugène Ionesco probably rank as the best-known Romanian-born artists. But each man did most of his work in France. Enesco's masterpieces, called *Romanian Rhapsodies,* are based on Romanian folk music. Some of Brancusi's sculptures contain elements of Romanian folk art. Ionesco's plays show some influence of his youth in Romania before the outbreak of World War II in 1939.

Land and climate

Romania covers 237,500 square kilometres. It measures about 724 kilometres from west to east and 515 kilometres from north to south. The Black Sea borders Romania in the southeast for 209 kilometres. Moldova lies to the north and northeast, Ukraine to the east, Hungary and Yugoslavia to the west, and Bulgaria to the south.

Surface features. A series of mountain ranges curves through northern and central Romania, forming a circular pattern. The mountains surround a vast flatland called the Transylvanian Plateau. The mountains are, in turn, surrounded by plains on the east, south, and west.

Romania's mountains are all part of the Carpathian Mountain System. The Moldavian, or Eastern, Carpathian range extends from the northern border to the centre of the country. The Transylvanian Alps, or Southern Carpathians, stretch westward from the Moldavian range. The Bihor Mountains and other ranges make up the Western Carpathians, which run through western Romania. Romania's mountains are neither extremely high nor steep, and several passes cut through them. As a result, they are not major barriers to transportation. Most of them are from 910 to 1,800 metres high. Mount Moldoveanu, in the Transylvanian Alps, is Romania's

Religious paintings decorate the outside walls of many Romanian churches. This form of art developed in Romania during the 1500's to remind passers-by of their religious faith.

Romania map index

Cities and towns

Adjud	17,016	C	6
Aiud	28,904	C	3
Alba Iulia	61,733	C	3
Alexandria	49,239	F	4
Arad	182,997	C	1
Bacău	169,503	C	5
Baia Mare	131,268	B	3
Băileşti	21,990	F	3
Balş	19,539	E	3
Bîrlad	67,878	C	6
Bistriţa	70,246	B	4
Blaj	23,178	C	3
Bocşa	21,784	D	1
Botoşani	99,886	A	5
Brad	19,243	C	2
Brăila	228,035	D	6
Braşov	334,992	D	4
Breaza	18,353	D	5
Bucharest	1,961,189 *2,227,568	E	5
Buftea	17,465	E	5
Buhuşi	20,927	C	5
Buzău	129,510	D	5
Calafat	18,297	F	2
Călăraşi	64,561	E	6
Caracal	35,178	F	3
Caransebeş	31,702	D	2
Carei	27,182	A	2
Cîmpia Turzii	27,248	C	3
Cîmpina	37,673	D	5
Cîmpulung	39,826	D	4
Cîmpulung Moldovenesc	21,310	B	4
Cisnădie	21,465	D	3
Cluj-Napoca	299,786	B	3
Comăneşti	20,658	C	5
Constanţa	318,799	E	7
Corabia	21,118	F	4
Craiova	267,474	E	3
Curtea de Argeş	28,866	D	4
Dej	38,886	B	3
Deva	75,695	D	2
Dorohoi	28,172	A	5
Drăgăşani	18,405	E	4
Drobeta-Turnu Severin	94,964	E	2
Făgăraş	40,873	D	4
Fălticeni	26,346	B	5
Feteşti	31,505	E	6
Focşani	80,470	D	6
Galaţi	286,110	D	6
Gheorghe Gheorghiu-Dej	51,269	C	5
Gheorgheni	22,614	C	4
Gherla	22,209	B	3
Giurgiu	63,591	F	5
Hunedoara	87,528	D	2
Huşi	27,582	C	6
Iaşi	310,158	B	6
Lipova	12,723	C	2
Luduş	17,227	C	3
Lugoj	51,876	D	2
Lupeni	30,410	D	3
Mangalia	35,384	F	7
Marghita	17,642	B	2
Medgidia	47,205	E	7
Mediaş	71,514	C	4
Miercurea-Ciuc	44,421	C	5
Moldova Nouă	18,297	E	2
Odorheiu Secuiesc	38,977	C	4
Olteniţa	28,270	F	5
Oradea	206,056	B	2
Orăştie	23,034	D	3
Petrila	25,955	D	3
Petroşani	47,307	D	3
Piatra Neamţ	105,108	B	5
Piteşti	151,741	E	4
Ploieşti	232,462	E	5
Rădăuţi	27,412	A	5
Reghin	35,187	B	4
Reşiţa	102,564	D	2
Rîmnicu Sărat	34,886	D	5
Rîmnicu Vîlcea	89,479	D	3
Roman	69,329	B	5
Roşiori de Vede	33,074	F	4
Săcele	33,821	D	5
Salonta	21,082	B	2
Satu Mare	125,819	A	3
Sebeş	29,892	C	3
Sibiu	173,115	D	3
Sighetul Marmaţiei	42,546	A	3
Sighişoara	35,849	C	4
Sinaia	15,109	D	4
Sînnicolau Mare	13,637	C	1
Slatina	70,999	E	3
Slobozia	43,626	E	6
Suceava	89,521	B	5
Tecuci	42,950	D	6
Timişoara	309,258	D	1
Tîrgovişte	85,705	E	4
Tîrgu Jiu	82,627	D	3
Tîrgu Mureş	152,258	C	4
Tîrgu Neamţ	18,391	B	5
Tîrnăveni	28,714	C	4
Topliţa	16,243	B	4
Tulcea	80,888	D	7
Turda	60,544	C	3
Turnu Măgurele	33,069	F	4
Urziceni	15,892	E	5
Vaslui	59,600	C	6
Vatra Dornei	18,019	B	4
Vişeu de Sus	21,423	A	4
Vulcan	32,589	D	3
Zalău	51,781	B	3
Zărneşti	26,097	D	4
Zimnicea	16,992	F	4

*Population of metropolitan area, including suburbs.
Source: 1984 census, except for Bucharest metropolitan area, which is a 1983 official estimate.

Physical features

Argeş River	E	4
Bega Canal	D	1
Bihor Mountains	C	2
Bîrlad River	C	6
Bistriţa River	B	5
Black Sea	F	7
Buzău River	D	6
Calimani Mountains	B	4
Codru Mountains	C	2
Crişul Alb River	C	2
Crişul Repede River	B	2
Danube-Black Sea Canal	F	7
Danube (Dunărea) River	E	6
Dîmboviţa River	E	4
Harghita Mountains	C	4
Ialomiţa River	E	5
Jiu River	E	3
Lake Razelm	E	7
Lake Sinoe	E	7
Moldova River	B	5
Moldoveanu (mtn.)	D	4
Mureş River	C	4
Olt River	F	4
Pietrosul (peak)	B	4
Prut River	B	6
Rodnei Mountains	B	3
Siret River	A	5
Someş River	B	3
Transylvanian Alps (mountains)	D	3

highest mountain. It rises to a height of 2,543 metres.

The Transylvanian Plateau lies about 366 metres above sea level and Romania's plains lie at or near sea level. These flatlands have the country's best farmland and most of its cities and towns. Vast forests cover parts of the Transylvanian Plateau and the mountains.

Romania has many rivers. The longest and most important one by far is the Danube River. It flows about 1,400 kilometres through Romania. Most of the way, it flows west to east along the southern border. The Danube turns northward near the Black Sea, then eastward again, and empties into the sea. Most of Romania's other major rivers flow into the Danube from the north. They include, from west to east, the Jiu, Oltul, Argeş, Ialomiţa, Siretul, and Prut.

Romania has about 2,500 lakes. Most of them are small. The biggest lakes lie near the Danube. Numerous tiny lakes add beauty to Romania's mountains.

Land regions. Romania can be divided into six land regions. They are Transylvania, Bukovina, Moldavia, Walachia, Banat, and Dobruja.

Transylvania is the country's largest and most varied region. It extends throughout central and northwestern Romania, and includes most of the country's mountains, the Transylvanian Plateau, and the northwestern plain. The plateau and plain have good soil for farming. The plateau and the mountains yield valuable forest products and minerals. The beauty of the mountains and their ski slopes and other recreation facilities make them a favourite vacation area. Several cities have grown up in Transylvania because of its rich resources.

Bukovina, northeast of Transylvania, is a thickly forested region in the Moldavian Carpathian Mountains. It has ski slopes and lovely scenery. The people of Bukovina live in small villages in the valleys.

Moldavia, Walachia, and Banat. Moldavia, in northeastern Romania, extends from Transylvania to the Prut River along the border with Moldova. Walachia, in the south, stretches from the southernmost mountains to the Danube. Banat, in western Romania, extends from the western mountains to Yugoslavia and Hungary. All three of these regions have a similar physical makeup. The land in each descends from mountains near Transylvania, to hills, and then to plains. These plains are Romania's best farmland. Walachia has more people than any other Romanian region, chiefly because Bucharest is there. Banat has several cities, but Moldavia has few.

Dobruja is a small plain between the northern course of the Danube River and the Black Sea. The Danube Delta covers northeastern Dobruja. This marshy area has an amazing variety of wildlife. Sturgeon, the source of caviar, and numerous other kinds of fish live in its waters. About 300 species of birds, including the pelican, also live in the delta. Farmland covers most of southern Dobruja. The Danube-Black Sea Canal flows through this area. Completed in 1984, it provides a shortcut from the Danube to the Black Sea. Sandy beaches and beautiful seaside resorts line Dobruja's Black Sea coast. The major

In the Transylvanian Alps new resorts provide hiking holidays in summer and skiing in the winter. Tourism helps to bring foreign currency into Romania.

Land regions of Romania

The map below shows the six land regions of Romania: Transylvania, Bukovina, Moldavia, Dobruja, Walachia, and Banat.

port city in Romania is Constanţa, which is located on the coast.

Climate. Romania has hot, sunny summers and cold, cloudy winters. The average July temperature is 21° C, and the average January temperature is −1° C. Romania's plains are warmer than its mountain areas. *Precipitation* (rain, melted snow, and other forms of moisture) ranges from about 100 centimetres yearly in some mountain areas to less than 50 centimetres on the plains.

Economy

Before the 1960's, Romania's economy was based on agriculture. But then, with steps taken by the Communist government, industry—including manufacturing, mining, and construction—passed agriculture as the leading producer of income in Romania. Industry also passed agriculture as the leading employer.

Under the Communists, the national government controlled Romania's economy. It owned the country's factories, mines, and banks, and owned or controlled most of its farms. It decided how much of each product should be produced, and it set the price of most goods. After the 1989 revolution, the non-Communist government loosened government control of the economy and allowed some private enterprise. In mid-1992, the government began selling shares in state-owned companies and distributing vouchers that could be exchanged for shares in other state-owned businesses.

Natural resources. About 60 per cent of Romania's land is fertile cropland and rich pastureland. Another 25 per cent has forests that provide timber. The mountains and plateau have valuable mineral deposits. Natural gas and petroleum rank as the most important minerals. Other important minerals include bauxite, coal, copper, gold, iron ore, lead, silver, and zinc.

Industry. Romania had very little industry when the Communists took over. To get industry started, the Communists stressed the production of *capital goods.* Capital goods include raw materials needed for industry, buildings in which industrial work is done, machines and tools needed to do the work, and power plants that supply energy for the work. Production of *consumer goods* (those manufactured for use by people) lags far behind production of capital goods.

The manufacture of machinery for farms, factories, and mines is the leading industrial activity. Romania also produces cement and other construction materials, iron and steel, petroleum products, and wood products. Food processing and the manufacture of clothing and shoes are the only consumer goods activities among the top industries in Romania. Bucharest is the chief industrial centre. Other industrial centres include Braşov, Cluj-Napoca, Ploieşti, and Timişoara.

Services. Trade and transportation are the leading employers among service industries in Romania. These industries are responsible for getting the country's agricultural and industrial products from producers to buyers. Other service activities include education, health care, housing, and national defence.

Agriculture. Crops account for about three-fifths of the value of Romania's agricultural products, and livestock for about two-fifths. Grains, especially maize and wheat, are the leading crops. Other crops include grapes and other fruit, potatoes, and sugar beet. Farmers raise more sheep than any other kind of livestock. They also raise cattle, horses, pigs, and poultry.

In pre-Communist days, almost all of Romania's farmland was privately owned. But the Communist government gradually took control of 90 per cent of the land. It created collective farms and state farms.

Hundreds of families worked together on each collective farm. Workers received wages and farm products, and part of the income earned from the sale of the products. Officially, the people owned the collectives. State farms were owned and operated by the government. The farmers received wages. The government provided much modern farm equipment for the state farms. But collective farmers still relied heavily on old-fashioned equipment.

Heavy machinery is Romania's leading manufactured product. Each year, the country's latest agricultural and industrial products are displayed at an exhibition held in Bucharest, *above.*

Agriculture employs many Romanians. Although large state farms have modern equipment, many smaller farms, *above,* use old-fashioned methods.

After the 1989 revolution, the government passed laws that allowed some collective farms to be broken up and their land redistributed to farmworkers. Some farmers whose lands had been taken away by the Communists were again able to own their own farms. The land-reform laws did not break up state farms. However, farmers whose land had been incorporated into the state farms were to be issued shares of stock in new agricultural companies. These companies were designed to replace state farms. By the end of 1991, almost 70 per cent of agricultural land in Romania was privately owned.

Trade. Industrial machinery, fuels, and chemicals are both important exports and imports. Other exports include cement, clothing and shoes, processed foods, and timber. Iron ore, coal, and cotton are major imports.

Until the 1960's, Romania carried on about 80 per cent of its trade with the Soviet Union and other Communist nations. But in the 1960's—as part of its policy to free itself from Soviet control—the country began expanding its trade with Western European nations and the United States. Today, however, Romania's major trading partners still include the countries that made up the former Soviet Union, which broke up in 1991.

Transportation and communication. Trains are Romania's chief means of long-distance travel. Buses provide most of the transportation within cities. Fewer than 2 per cent of Romanians own a car. Bucharest has the nation's main airport. The government owns Romania's only airline and its railways and bus services.

About 40 daily newspapers are published in Romania. The government owned most of the radio and television stations under Communism, but many independent stations were set up in the early 1990's. Romania has an average of only about one television set for every six people. About one of every three people has a radio.

History

Romanians trace their history back to the 300's B.C. But Romania did not become an independent, unified country until 1861. Most of the time in-between, various foreign peoples ruled all or part of Romania.

Early days. Historians do not know when Romania was first settled. But a people called the Dacians were living there by the 300's B.C. The Dacians farmed, mined gold and iron ore, and traded with neighbouring peoples. Romania was called *Dacia* during this period.

The Romans, under Emperor Trajan, conquered Dacia in A.D. 106 and made it a province of the Roman Empire. The Romans intermarried with the Dacians, who adopted Roman customs and the Latin language. Dacia became known as *Romania* because of the Roman occupation and influence.

Barbarians from the east and north began invading Romania during the A.D. 200's. They forced the Romans to abandon the province in the late 200's. The invasions continued off and on until the 1100's. The invaders were Bulgars, Goths, Huns, Magyars, Slavs, and Tatars.

Unification movement. For hundreds of years, various groups fought for control of the region. The first steps toward unification took place between 1250 and 1350. The people of Walachia, a region in southern Romania, gradually united and formed an independent state. The people of Moldavia, in eastern Romania, did the same. A prince ruled each state, which is why they were called *principalities.*

Earlier, during the 1000's, Hungary had taken over most of what is now northern Romania. This area, called *Transylvania,* had many Romanian people. But it did not become part of Romania until the 1900's.

Turkish rule. The independence of the principalities was short-lived. The Ottoman Turks of Asia Minor (now Turkey) swept into Europe in the mid-1400's. They conquered Walachia in 1476 and Moldavia in 1504. The Turks ruled these lands almost continuously for over 300 years. The peasants in the principalities led hard lives even before the Turks took over. They were poor farmers, but they had to pay high taxes to the ruling nobles. Conditions grew worse under the Turks, who let Romanian nobles rule in their name, but demanded increased taxes from the peasants for themselves.

The Romanian nobles made several attempts to gain freedom from the Turks. As a result, in the early 1700's, the Turks sent wealthy Greeks to govern the principalities. These Greeks were called *Phanariots* because they came from the Phanar district of Constantinople, Turkey. They taxed the peasants far more than ever before and treated them harshly. Phanariot rule lasted until 1821, when a revolt by Romanians forced the Turks to remove the Greeks from power. Many scholars believe that Romania's peasants never suffered more than they did during the Phanariot period.

Russian control. During the late 1700's, the Turks suffered a series of military defeats at the hands of Russia. Little by little, Turkey lost parts of its empire. Officially, Turkish rule of the principalities lasted until 1878. But, in effect, it ended in 1829, when Russian troops occupied the principalities.

Russia drew up a constitution for the principalities in the early 1830's. The constitution, called *Organic Statutes,* gave governing power in each principality to an assembly of nobles. This marked the beginning of representative government in Romania. Russia's troops withdrew from the principalities in 1834.

The origins of modern Romania. The idea of uniting Moldavia and Walachia existed almost from the time the principalities were founded. The unification movement grew rapidly during the mid-1800's. In 1859, the assemblies of the two principalities elected Prince Alexander John Cuza as their common ruler. In 1861, the principalities officially united to form a nation called *Romania.*

Many of the leaders of the unification movement were young Romanians who had studied in Paris. There, they learned about a revolutionary spirit that was sweeping through Europe. Many Europeans were demanding an end to undemocratic government and calling for improvements in living conditions for the lower classes. The young Romanians demanded reforms after they returned home. Prince Cuza responded. His government bought much land from wealthy Romanians and gave it to peasants. It also increased the number of free schools for the poor. Many of the wealthy Romanians opposed Cuza. They forced the prince to resign in 1866.

The wealthy Romanians selected Karl of Hohenzollern to replace Cuza. Karl was a German prince who knew little about Romania. According to one story, he even had to consult a map to learn where the country was. But he was to rule Romania for nearly 50 years.

Karl took the name Prince Carol. In 1878, the major nations of Europe officially recognized Romania's full independence from Turkey. In 1881, Romania became a kingdom, and Carol became King Carol I.

At the start of Carol's reign, Romania's first political parties were established, and the people were given the right to elect their government representatives. But a complex election system kept the peasants from having many representatives. Romania's economy improved under Carol. Wealthy Romanians benefitted from the economic growth, but the peasants gained little from it. In 1907, Romania's peasants revolted. They burned the houses and destroyed the crops of many wealthy landowners. The Romanian Army put down the revolt, killing at least 10,000 peasants. Carol died in 1914, and his nephew Ferdinand became king.

World War I was fought from 1914 to 1918. Romania remained neutral at first. But in 1916, it joined France, Great Britain, and the other Allies in their fight against the Central Powers (chiefly Austria-Hungary and Germany). Romania wanted to gain Banat, Bukovina, and Transylvania—three provinces of Austria-Hungary that had large Romanian populations. The Allies won the war, and Romania received the territories it wanted as part of the peace settlement. As a result, Romania almost doubled in size and population. For the first time, Romania's territory included almost all the land where large numbers of Romanians lived.

Depression and fascism. Liberal political parties headed Romania's government after World War I. They divided the estates of many of the wealthy landowners into small farms and sold the farms to peasants. The liberals wanted to continue helping the peasants, but a worldwide depression that began in 1929 destroyed the economy of Romania. Millions of Romanians lost their jobs, and poverty became severe throughout the country.

Romania's economic problems caused many people to seek new leadership in the early 1930's. The Iron Guard soon became a strong authoritarian movement. Its followers were fascists who sought to destroy Romania's government and establish a dictatorship. This group used terror against its political opponents and blamed Communists, Jews, and liberals for Romania's problems.

King Ferdinand died in 1927, and his son Carol became King Carol II three years later. The popularity and power of the Iron Guard grew during the early years of Carol's reign. Fearing a loss of his own authority, Carol made himself dictator of Romania. He outlawed the Iron Guard and all political parties.

World War II began in Europe in September 1939, as a struggle between Germany and the Allies—a group of nations led by France and Great Britain. Romania remained neutral at the beginning. By June of 1940, Germany had gained a great military advantage over the Allies. Germany allowed Hungary to take northern Transylvania from Romania. The Soviet Union took part of northeastern Romania. Bulgaria took territory in the southeast.

The territorial losses turned the people against King Carol, and he gave up his throne on Sept. 6, 1940. Carol's

Romania—History The maps below show three major stages in Romania's history. The map on the left shows the principalities of Moldavia and Walachia before they fell under Turkish control. The centre map shows Romania when it became a nation, in 1861. The map on the right shows Romania before the outbreak of World War II, in 1939. The boundaries of present-day Romania are shown in red.

1350

1861

1939

son Michael became king, but Premier Ion Antonescu ruled. Antonescu cooperated with Germany, and German troops occupied Romania in October. Romania then joined the war on the side of Germany.

By August 1944, the tide of the war had turned against Germany. King Michael then overthrew Antonescu, and Romania joined the Allies. The war ended in 1945, and the Allies took northern Transylvania from Hungary and returned it to Romania. The Soviet Union and Bulgaria kept the Romanian territory they had taken.

Communist control. The Soviet Union had been formed as a Communist nation under Russia's leadership in 1922, and it existed until 1991. During World War II, the Soviet Union fought on the side of the Allies. Soviet troops occupied Romania in 1944 and stayed there until the late 1950's.

Romania's Communist Party had never been strong before World War II. But under the protection of the Soviet troops, Romanian Communists took over the government after the war. They killed or imprisoned their political opponents, and forced King Michael to give up his throne on Dec. 30, 1947.

The Communists declared Romania an "independent people's democracy." But Romania was, in reality, a *Soviet satellite* (country controlled by the Soviet Union). In 1948 and 1952, Romania adopted constitutions that praised the Soviet Union. Romania's government, educational system, and several other institutions were modelled on those of the Soviet Union. Soviet leaders directed Romania's economy and forced the country to emphasize agriculture and neglect industry. They also controlled Romania's foreign policy.

Opposition to the Soviet Union. Resentment of Soviet interference in Romania's affairs grew during the 1950's. In the early 1960's, Romania's Communists—led by Communist Party head, Gheorghe Gheorghiu-Dej—began to oppose this interference openly. Gheorghiu-Dej died in 1965. Nicolae Ceausescu, who succeeded him as party head, continued the opposition.

In 1962, Romania insisted that each Communist country should be free to develop its own economic system, trade freely with all nations, and make its own foreign policy. Romania's leaders then began expanding industry and increasing trade with Western nations. In 1964, Romania exchanged ambassadors with the United States. Romania's leaders hosted a visit by U.S. President Richard Nixon in 1969. They also declared Romania neutral in a dispute between the Soviet Union and China. In 1965, Romania adopted a Constitution that called for the nation's complete independence. In 1977, Romania began strengthening its ties with the nations of the *nonaligned movement.* These nations, primarily in Asia and Africa, refused to support either the Communist or non-Communist bloc.

Also in 1977, an earthquake struck Bucharest and other parts of Romania. It caused about 1,500 deaths and extensive damage to property.

The government's industrialization policy has increased the size of Romania's urban communities. Each year, thousands of young people moved from rural areas to cities to work in industry and government.

In the 1980's, new jobs were created, but Romania's living standard remained low and consumer goods were scarce. Reasons for the struggling economy included corruption in the Communist Party and overreliance on central government economic planning. In addition, Romania had to borrow heavily from Western European banks to finance its industrial build-up. Paying off this debt took funds away from further development and slowed economic growth.

Recent developments. Ceausescu's government maintained an extensive system of restrictions on the lives of the Romanian people. In mid-December 1989, thousands of people in the Romanian city of Timişoara staged demonstrations, calling for greater freedom from the Communist government and for an improved standard of living. Government security forces responded to the protests by firing on the people and killing hundreds. Antigovernment protests then spread across Romania. In Bucharest, tens of thousands of people gathered in the streets and called for increased freedoms and the resignation of Ceausescu. Security forces fired on the crowds, bringing the death toll of demonstrators into the thousands. Army units joined the revolt, and fierce fighting between the army and Ceausescu's security forces followed.

On December 22, Ceausescu and his wife, Elena, fled Bucharest during a massive antigovernment demonstration. However, they were soon captured by the army. A secret trial took place and Ceausescu and his wife were charged with murder and embezzlement of government funds. They were found guilty and were executed on December 25. The National Salvation Front, a group made up chiefly of former Communist Party officials and members, took control of the government. Ion Iliescu, leader of the Front, became the acting president of Romania. The Front cancelled a number of Ceausescu's restrictions on freedom. Free multiparty elections took place in May 1990. Iliescu won the presidency, and the Front also won a wide majority in the legislature. Iliescu then stepped down as leader of the Front in accordance

Important dates in Romania

300's B. C. Dacians lived in what is now Romania.

A. D. 100's Romania became a province of the Roman Empire.

200's to 1100's Barbarian tribes invaded Romania.

1250 to 1350 Moldavia and Walachia gradually became independent principalities.

c. 1500 The principalities fell under Turkish rule.

1861 Moldavia and Walachia officially united and formed the nation of Romania.

1919 Romania almost doubled in size when Transylvania and other surrounding lands became part of it.

1940-1945 Romania fought in World War II—first on the German side and then on the side of the Allies.

1947 Romania officially became a Communist country.

1950's The Soviet Union had nearly complete control over Romania.

1965 A new Romanian Constitution stressed the nation's control over its own affairs.

1977 An earthquake caused about 1,500 deaths and extensive property damage in Romania.

1989 Communist Party leader Nicolae Ceausescu was overthrown and executed following widespread protest over his policies and corruption in his government.

1990 Romania held its first free multiparty elections since the end of World War II. A non-Communist party gained control of the government.

with a law established in early 1990. The law states that the head of state cannot be a political party leader.

Opposition parties complained of abuse and intimidation by members of the ruling party during the election. In mid-1990, progovernment and antigovernment demonstrators clashed on the streets of Bucharest. Hundreds were injured. Large antigovernment demonstrations continued in the early 1990's, often in protest against economic conditions. In late 1991, following strikes and riots staged by miners, the government of the National Salvation Front resigned. It was replaced by a coalition government dominated by the Front. Iliescu remained president. New national elections were held in 1992. Iliescu was reelected president. But in this election, he represented a political party called the Democratic National Salvation Front. This party broke away from the National Salvation Front in 1992.

Related articles in *World Book* include:

Biographies

Brancusi, Constantin	Ceausescu, Nicolae
Carol I	Ionesco, Eugène
Carol II	Steinberg, Saul

Other related articles

Balkans	Moldova
Bessarabia	Russo-Turkish Wars
Black Sea	Transylvania
Bucharest	Warsaw Pact
Carpathian Mountains	World War I
Danube River	

Outline

I. **Government**
- A. National government
- B. Political parties
- C. Local government
- D. Courts
- E. Armed forces

II. **People**
- A. Ancestry and population
- B. Language
- C. Way of life
- D. Recreation
- E. Food and drink
- F. Education
- G. Religion
- H. Arts

III. **Land and climate**
- A. Surface features
- B. Land regions
- C. Climate

IV. **Economy**
- A. Natural resources
- B. Industry
- C. Services
- D. Agriculture
- E. Trade
- F. Transportation and communication

V. **History**

Questions

Who were the first known people to live in Romania?
What are some of Romania's natural resources?
How did the Communists influence life in Romania?
How did Romania get its name?
Who was Nicolae Ceausescu? Ion Iliescu?
What are some favourite recreational activities in Romania?
Why is the Romanian language unusual?
What was the Iron Guard?
What are some features of Romania's folk culture?
What is a collective farm? A state farm?

Romanov was the name of the family that ruled Russia from 1613 to 1917. The first Romanov ruler was Czar Michael, the son of Czar Ivan IV and Anastasia Romanov. Michael was elected czar in 1613. His son, Czar Alexis, acquired Ukraine and sponsored the introduction of Western education, technology, and military methods in Russia.

Sixteen more Romanov rulers followed. One of the most famous was Alexis' son Peter the Great. Rulers after 1762 either were foreigners or had little Russian ancestry, but they kept the Romanov name. The last Romanov ruler, Czar Nicholas II, gave up his throne in March 1917. He and his immediate family were almost certainly murdered in July 1918, by Communist revolutionaries. Other family members survived and escaped from Russia.

Related articles in *World Book* include:

Alexander I (czar)	Nicholas I (czar)
Alexander II (czar)	Nicholas II (czar)
Alexander III (czar)	Peter I, the Great
Catherine (II)	Russia (History)

Romanov, Grigoriy Vasilyevich (1923-), was a leading official of the Communist Party of the Soviet Union. Until 1991, the Communist Party controlled the Soviet government. Romanov served as a full member of the party's Politburo from 1976 to 1985, and as a member of the Secretariat of the party's Central Committee from 1983 to 1985. He also belonged to the Presidium from 1970 to 1985. The Politburo made the party's policies, and the Secretariat managed its daily affairs. The Presidium was an important body of the Soviet government. In 1985, Romanov asked to be removed from his posts for health reasons. But many analysts think he was removed because he had lost influence in the party.

Romanov was born in Zikhnovo, near Novgorod. He joined the Communist Party in 1944. Beginning in the mid-1950's, he held a series of increasingly important positions in the Communist Party.

Romans, Epistle to the, the sixth book of the New Testament of the Bible is a letter from the apostle Paul to the Christians in Rome. Paul wrote it, probably from Corinth, Greece, about A.D. 56. Paul had not founded the Christian community in Rome nor visited it previously. The Epistle was a letter of introduction, preparing for a visit Paul intended to make while on his way to do missionary work in Spain.

The Epistle to the Romans is Paul's longest and most systematic letter. The main theme of the first 11 chapters is that Jews and Gentiles are equally in need of salvation, and that both have access to salvation through faith in Jesus Christ. In the five remaining chapters, Paul discusses problems in Christian living. Some scholars doubt that chapter 16 was originally part of the letter, mainly because Paul, who had never been to Rome, greets many people by name in this chapter. These scholars believe that the chapter is a letter Paul wrote to another place, which a later editor attached to the letter to the Romans.

See also **Paul, Saint** (Paul's letters and ideas); **Bible** (Books of the New Testament).

Romanticism is a style in the fine arts and literature. It emphasizes passion rather than reason, and imagination and intuition rather than logic. Romanticism favours full expression of the emotions, and free, spontaneous

action rather than restraint and order. In all these ways, romanticism contrasts with another style called *classicism* (see **Classicism**). Periods of romanticism often develop as a revolt against classicism. Artists and writers throughout history have shown romantic tendencies. But the term *romantic movement* usually refers to the period starting in the late 1700's and ending in the mid-1800's.

The qualities of romanticism

Romantics yearn for the infinite. The English romantic poet William Blake thought he could "see a World in a Grain of Sand/And a Heaven in a Wild Flower." Romantics view nature as a living spirit, attuned to human feelings of love and compassion.

Romanticism stresses freedom for the individual. It does not favour restricting social conventions and unjust political rule. In literature, the romantic hero, such as Lord Byron's "Manfred," is often a rebel or outlaw.

Just as the romantic hero is in revolt against social conventions, the romantic artist is in revolt against artificial ideas of good form. In drama, for example, romantic writers reject the classical unities of time, place, and action. They allow the events in their plays to range widely in time and space. Jean Racine's play *Phèdre* is rigidly classical in form. Johann Wolfgang von Goethe's play *Faust* is romantic.

Romanticism in the arts

Romanticism in literature. During the romantic movement, most writers were discontented with their world. It seemed commercial, inhuman, and standardized. To escape from modern life, the romantics turned their interest to remote and faraway places, the medieval past, folklore and legends, and nature and the common people. The romantics were also drawn to the supernatural.

Many romantic characteristics were united in the *Gothic novel.* This was a type of horror story, filled with violence and supernatural effects, and set against a background of gloomy medieval Gothic castles. The Gothic novel influenced the American writers Nathaniel Hawthorne and Edgar Allan Poe. The novels of Sir Walter Scott of Scotland reveal the typically romantic interest in the past. *Grimm's Fairy Tales,* collected by the German brothers Jakob and Wilhelm Grimm, are famous examples of the romantic interest in legends and folklore.

Many typically romantic characteristics appear in the poetry of William Wordsworth of England. Wordsworth preferred a reflective "vacant and pensive mood" to a restless search for scientific knowledge. He believed we learn more by communing with nature or talking to country people than by reading books. He also believed that harmony with nature is the source of all goodness and truth.

Romanticism in painting. Romantic painters often used bold lighting effects and deep shadow to cast a visionary gleam over their subjects. Classical forms and themes were abandoned for faraway exotic subjects such as the Oriental scenes painted by the Frenchman Eugène Delacroix. Dramatic scenes of nature were also popular. Compare Nicolas Poussin's classical painting *St. John on Patmos* with the romantic painting *Stoke-by-Nayland* by John Constable. Both paintings appear in the **Painting** article.

Romanticism in music. Romantic composers modified the formalism of classical music, and aimed at lyric expression and organic unity. Many of these composers gave their works a nationalistic character by using folk songs as themes. Romantic composers include Franz Schubert of Austria; Felix Mendelssohn, Robert Schumann, and Carl Maria von Weber of Germany; and Frédéric Chopin of Poland.

Romanticism and society. The French philosopher Jean Jacques Rousseau taught that people are naturally good, but have been corrupted by the institutions of civilization. He idealized the *noble savage,* an individual unspoiled by luxury and sophistication, and he argued that in a virtuous society children would grow up honest and free. Influenced by these ideas, many romantics opposed political tyranny and took part in liberal and revolutionary activities. The revolutions in America and France during the late 1700's were influenced by romantic ideals. Many of Rousseau's theories influenced educational theory and practice. Romanticism also became associated with economic and social reform, especially in the United States.

Related articles. There is a separate biography in *World Book* for each person discussed in this article. For the historical development of romanticism, see:

Classical music (The romantic era)
Drama (Romanticism)
English literature (Romantic literature)
French literature (Romanticism)
German literature (1750-1830)
Gothic novel
Latin-American literature (Romanticism)
Literature (Romanticism)
Painting (The 1800's)
Poetry (Romantic poetry)
Russian literature (The age of romanticism)
Sculpture (1600-1900)
Spanish literature (Neoclassicism, romanticism, and realism)

Romberg, Sigmund (1887-1951), was a famous composer of operettas. He wrote the music for such famous operettas as *Maytime* (1917), *The Student Prince* (1924), *The Desert Song* (1926), *My Maryland* (1927), *The New Moon* (1928), and *Up in Central Park* (1945). He adapted the music of the Austrian composer Franz Schubert for another popular operetta, *Blossom Time* (1921). Romberg's many popular songs include "Deep in My Heart, Dear," "The Desert Song," "Stouthearted Men," and "When I Grow Too Old to Dream." He also wrote music for films and gained praise as a conductor of light classical music.

Romberg was born in Nagykanizsa, Hungary. Although he studied the violin as a child, Romberg planned to become an engineer. To help finance his engineering studies in a Vienna technical school, he worked as assistant manager at the Theater-an-der-Wien, Vienna's leading theatre for operettas. The productions Romberg saw there convinced him to pursue a career in music.

In 1909, Romberg moved to New York City and eventually formed a small orchestra. Romberg was soon hired to write songs for musicals presented by J. J. and Lee Shubert, two brothers who operated theatres throughout the United States. Romberg composed music in the American ragtime fashion for several years before he began writing the European-style operettas for which he became famous.

James Davis Travel Photography

The Spanish Steps in Rome are a popular meeting point, as well as a famous landmark. Many tourists visit the steps every year.

Rome

Rome is the capital of Italy and one of the world's great historic cities. It has been an important centre of civilization for over 2,000 years. Because of its long history, Rome is called the *Eternal City.* It is also one of the world's most beautiful cities, its historic centre standing on seven hills. Its ancient monuments and magnificent churches and palaces stand as reminders of Rome's past glory. Gleaming new buildings are a sign of its modern-day importance.

Rome ruled the ancient Western world as the capital of the mighty Roman Empire. For hundreds of years, Rome was the supreme power of Europe, northern Africa, and western Asia. Ancient Rome's influence can still be seen today in such fields as architecture, government, language, and law.

As the home of the popes, whose palace is in the independent Vatican City, Rome also became the centre of the Roman Catholic Church. During the 1500's and 1600's, the popes brought a new splendour to Rome. They hired great artists who gave the city beautiful buildings and priceless works of art. Thousands of visitors come every year from all parts of the world to enjoy these masterpieces, and to see the ruins of ancient Rome.

Visitors also enjoy the colourful life of sunny Rome. They stroll through the city's fashionable shops and open-air markets, or they take a ride in horse-drawn carriages. Like the Romans, visitors enjoy relaxing at pavement cafes or in the many beautiful squares. The people of Rome are friendly and proud of their city. They are happy to help strangers find their way or select the most delicious foods in restaurants, or just to chat.

Facts in brief about Rome

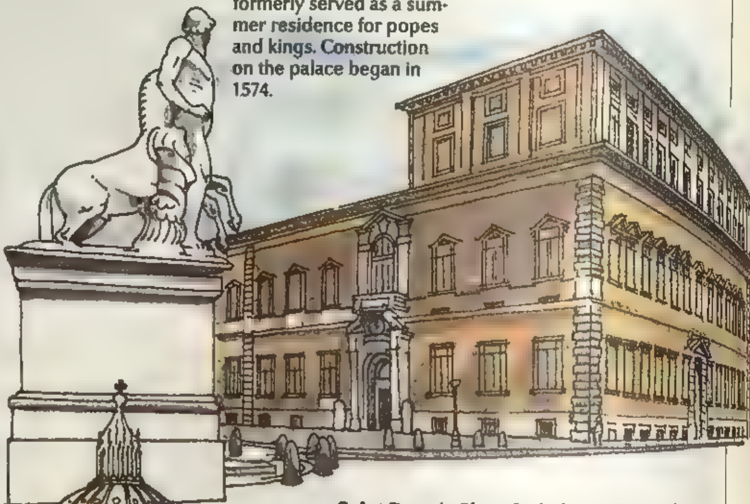
Population: 2,775,250.
Area: 1,508 km².
Climate: *Average temperature*—January 7 °C; July, 26 °C. *Average annual precipitation* (rainfall, melted snow, and other forms of moisture)—97 cm. For the monthly weather in Rome, see **Italy** (Climate).
Government: *Chief executive*—mayor (4-year term). *Legislature*—80-member City Council (4-year terms).
Founded: 753 B.C. (according to legend).

Rome *The Eternal City: Italy's ancient and modern-day capital.*

Capital and largest city of Italy (pop. 2,830,569). Lies on both banks of Tiber River in central Italy. City is on about 20 hills, including famous seven hills of ancient Rome—Aventine, Caelian, Capitoline, Esquiline, Palatine, Quirinal, Viminal.

City ranks as one of world's most important art centres. Ruins of ancient Rome lie scattered throughout the centre of the modern city. Masterpieces of Renaissance art and architecture attract visitors from all parts of world. Visitors also enjoy city's historic squares, fashionable shops, beautiful parks and gardens.

The Quirinal Palace, *below,* is the official home of the president of Italy. It formerly served as a summer residence for popes and kings. Construction on the palace began in 1574.



Saint Peter's Church, *below,* is Europe's largest Christian church. Numerous outstanding architects worked on it. Michelangelo designed the building's magnificent dome. In the foreground stands the Sant' Angelo bridge, adorned with angels designed by the sculptor Gian Lorenzo Bernini.

27 B.C.
Augustus became first Roman emperor.

44 B.C.
Julius Caesar, leader of Roman Empire, was assassinated.

509 B.C.
Romans drove out Etruscans, established a republic.

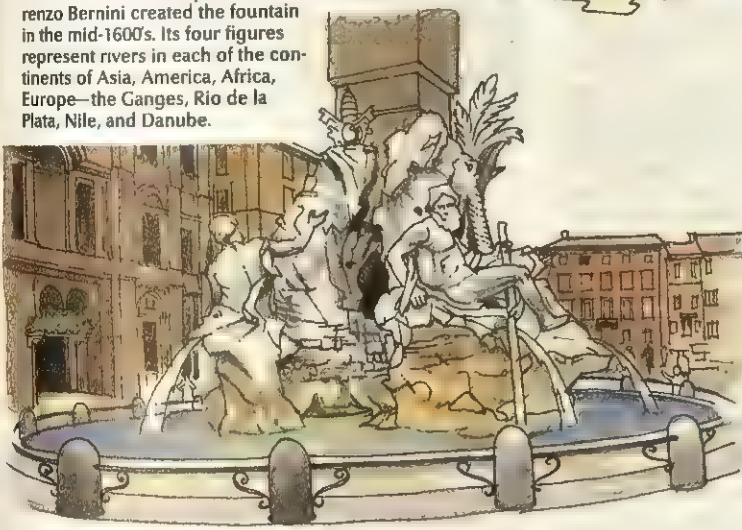
753 B.C.
Legendary founding of Rome by twin brothers Romulus and Remus.

A.D. 395
East and West Roman empires split apart.

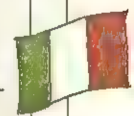
700's
Popes increased their political power; Papal States established.

The Colosseum, *right,* is the premier landmark of ancient Rome. This huge amphitheatre was the site of mock naval battles, combat between gladiators, battles between men and wild animals, and other public entertainment. The four-storey building seated about 50,000 spectators. It was in use primarily from A.D. 80 until the early 400's. However, some events continued there until the 500's.

Fountain of the Four Rivers, *below,* stands in a square called Piazza Navona. The sculptor Gian Lorenzo Bernini created the fountain in the mid-1600's. Its four figures represent rivers in each of the continents of Asia, America, Africa, Europe—the Ganges, Rio de la Plata, Nile, and Danube.



Vatican City, the governmental and spiritual centre of Roman Catholic Church, lies in northwestern Rome. Vatican is smallest independent state in world. It is ruled by the pope.



Vatican Palace houses many priceless artworks by Leonardo da Vinci, Michelangelo, Raphael, and other great masters. Vatican Library, established in 1400's.

An Estruscan bronze wolf, *above,* is displayed in the Capitoline Museum. The figures of Romulus and Remus (twin brothers who, according to tradition, founded Rome) were added around 1500.

The Roman Forum, *right,* was the centre of government in ancient Rome.

1500's and 1600's
Popes hired great artists who created magnificent buildings and artworks.

1870
King Victor Emmanuel II made Rome capital of Italy, ending pope's political power.

1929
Vatican City established as independent state.

1935
The University of Rome moved into its new campus, completed under direction of Fascist dictator Benito Mussolini.

1960
Summer Olympic Games held in Rome.

1976
E.U.R. (Universal Exhibition of Rome) project completed. Many large companies and government agencies there.

The city today

Rome lies on both banks of the Tiber River in central Italy, 16 kilometres east of the Tyrrhenian Sea. The city is on about 20 hills, but its outskirts have some wide stretches of flat ground. These hills include the famous seven hills on which ancient Rome was built—the Aventine, Caelian, Capitoline, Esquiline, Palatine, Quirinal, and Viminal hills.

Today, the ruins of ancient buildings cover most of the Aventine, Caelian, and Palatine hills. The Palatine also has a modern public park. Crowded commercial districts spread over the Esquiline and Viminal hills. The Italian presidential palace and some of Rome's government buildings stand on the Quirinal, the tallest of the seven hills. The streets of ancient Rome extended from the Capitoline, a centre of Roman life. Today, this hill has famous art museums, the City Council building, and a square designed by Michelangelo, the great Renaissance artist.

Throughout the city are many beautiful squares connected by busy streets. In the heart of Rome is the *Piazza Colonna* (Colonna Square). Banks, hotels, luxury shops, office buildings, restaurants, and theatres make it the busiest place in the city. Rome's main street, the *Via del Corso* (Way of the Course), runs 1.6 kilometres through the Piazza Colonna and links two other squares to the north and south. The *Via del Corso* got its name because it was used as a horse-racing course in the Middle Ages.

Vatican City, the administrative and spiritual centre of the Roman Catholic Church, lies in northwestern Rome. The Vatican, as it is sometimes called, is the smallest independent state in the world. It covers only 43.99 hectares, or about 0.4 square kilometre. See **Vatican City**.

Rome is also one of the world's most important art centres. Actors, musicians, painters, sculptors, and writers take part in the city's busy cultural life.

Parks and gardens. Romans enjoy the city's many public parks and gardens in the grounds of magnificent old *villas* (large estates). The villas were once owned by wealthy families. The great Villa Borghese, which was opened to the public in 1902, is the finest of these parks. Its hills, meadows, and woods seem like natural countryside. It also has a large zoo.

Many of Rome's tourists visit the Villa Ada, the old home of Italian kings. The Villa Glori, a park honouring Italy's war dead, is covered with pine trees. The Villa Sciarra has famous fountains and rare plants. Gardens on top of the Janiculum Hill are especially popular with children.

Music and theatre. The National Academy of St. Cecilia has one of Rome's leading symphony orchestras. Rome's orchestras also include the Rome Philharmonic and the Radiotelevisione Italiana. The world's oldest academies of music are in Rome.

Romans, like most Italians, enjoy opera. The Opera House offers performances from December to June. Rome's many theatres offer plays and musical comedies, including productions by companies from other countries.

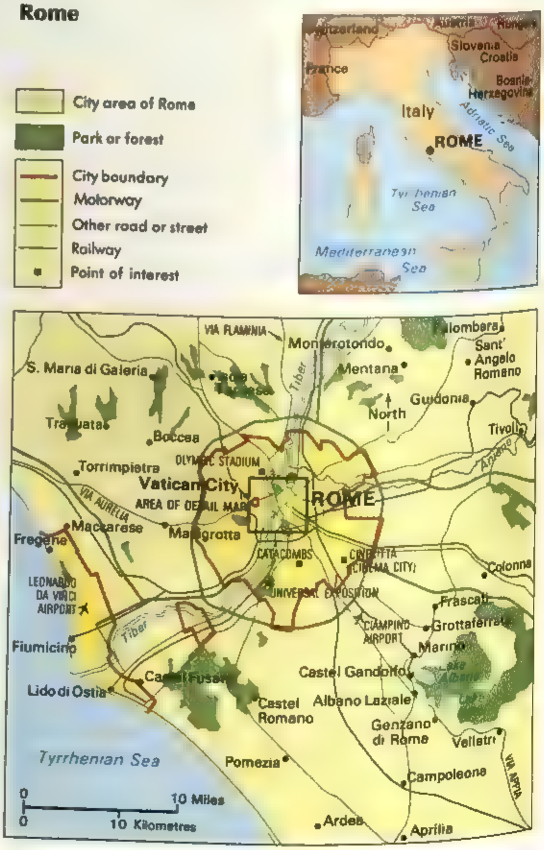
Museums and art galleries. Countless visitors come to see Rome's priceless art collections. Many of the finest paintings and statues are displayed in the Vatican Palace. They include masterpieces by such famous artists as Leonardo da Vinci, Michelangelo, and Raphael. Some of Michelangelo's greatest paintings decorate the ceiling and front wall of the Vatican's Sistine Chapel. See **Michelangelo** (pictures).

The oldest art collection in Rome, begun in 1471, is in the Capitoline Museum. It includes many fine sculptures of ancient Rome. The National Museum of the Villa Giulia has a collection of art from central Italy dating from pre-Roman times. Greek and Roman sculptures, and articles from ancient civilizations, are exhibited in the National Roman Museum. The Borghese Collection in the Villa Borghese includes works by almost every master of the Renaissance. The national Gallery of Modern Art has masterpieces that were produced chiefly in the 1800's and 1900's.

Churches, palaces, and fountains. Saint Peter's Church (also called Saint Peter's Basilica), in Vatican City is Europe's largest Christian church. It is an outstanding example of Renaissance architecture. Michelangelo helped design the church during the 1500's. Many famous art masterpieces can be seen inside (see **Saint Peter's Church**). Other well-known churches of Rome also date from the Renaissance, and from earlier and later periods.

The most famous of Rome's many palaces is the Venezia Palace, built during the mid-1400's. The Italian dictator Benito Mussolini established his office there in the Fascist period of the 1920's and 1930's. The palace now houses an art museum. The Madama Palace, once owned by the powerful Medici family, has been the seat of the Italian Senate since 1871. The Quirinal Palace is

Rome



The Fountain of Neptune in Rome's Piazza Navona, an historic square surrounded by beautiful churches and palaces.

The Baths of Caracalla were public baths dating from the A.D. 200's. Visitors enjoy the site's fine architecture.

the Italian president's official residence. It was the home of popes until 1870 and of kings of Italy from 1871 until 1946.

Rome has many magnificent fountains that are considered great works of art. The Trevi Fountain, which was completed in 1762, is the most popular with visitors from other countries. There is a legend that says that visitors who throw coins into this fountain will someday return to the city.

Schools. The University of Rome was founded in 1303 by Pope Boniface VIII. It has 180,000 students and is Italy's largest university (see **Rome, University of**). Various religious societies of the Roman Catholic Church operate a number of schools in Vatican City. There, students from many countries attend seminaries to become priests, or take university graduate studies. Some seminaries have been established for students from one country only. For example, the North American College has graduated about 1,800 American priests since it was founded in 1859.

Roman children must attend school between the ages of 6 and 14, which takes them through junior secondary school. They may also attend state schools at the next level of education. These schools include secondary schools and schools of fine arts, teacher training, and technical job training. Students pay small fees to attend all these higher-level schools. A number of independent schools are operated by religious groups.

The Vatican Library, established in the 1400's, is one of the most important libraries in the world. It owns many old Latin manuscripts (see **Vatican Library**). Rome also has nine public libraries with a total of about three million books. Other libraries are operated by Roman Catholic orders.

Sports. Soccer is Rome's most popular sport. Huge crowds attend club and international soccer matches in the Olympic Stadium. Horse shows are held in the *Piazza di Siena* (Siena Square) and the Capannelle and Tor di Valle Hippodromes. Other popular sports include basketball, boxing, and tennis.

Economy. Rome is not a heavily industrialized city. Most Romans earn their living in nonindustrial jobs, such as those in commerce and government. Many Romans work in restaurants and in the building trades. Tourism also provides a large part of the city's income. Only about a fifth of the workers in Rome are employed in industry. The city's factories produce clothing and textiles, processed foods, and other products. Most of the factories in Rome are located in the northwestern part of the city.

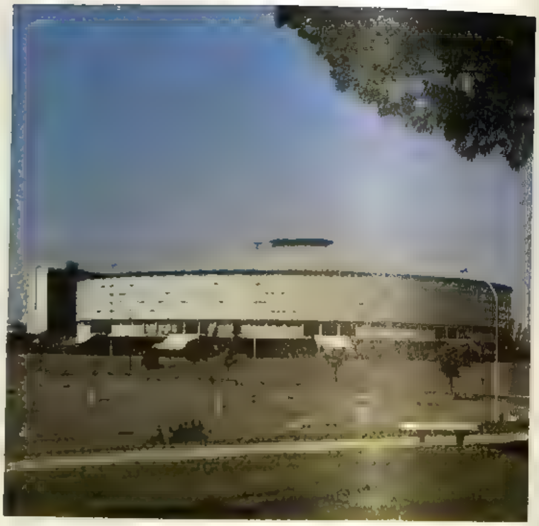
Film production is an important part of Rome's economy. The city is one of the film capitals of the world. Film companies of Italy and other countries have produced many famous films in Rome's studios and streets.

Rome is a major transportation centre of Italy. Railways and roads connect Rome with cities in most parts of the country. Airlines link the city with the rest of Italy and other parts of the world. Rome's central railway station is one of the largest and most beautiful stations in the world. The Metropolitana, Rome's underground system, runs southwest from the railway station to the port of Ostia. Buses, trams, taxis, and trolleybuses also serve Rome. Beginning in 1973, all private vehicles were banned from part of the ancient section of the city to reduce traffic jams and air and noise pollution.

Rome has many daily newspapers, of which the most important are *Il Messaggero* (The Messenger), *Il Tempo* (The Time), and *La Repubblica* (The Republic). The Vatican publishes the semi-official newspaper of the Roman Catholic Church, *L'Osservatore Romano* (The Roman Observer). Many other specialized newspapers are published in Rome, including *Corriere dello Sport* (Sport Courier). Some papers are official dailies of political parties. These include *Avanti!* (Forward!) of the Socialist Party, *Il Popolo* (The People) of the Christian Democratic Party, and *L'Unità* (Unity) of the Democratic Party of the Left. Italy's radio and television system, Radiotelevisione Italiana, has its headquarters in Rome.

Government. Rome is governed by a City Council consisting of 80 members, who are elected every four

The University of Rome, founded in 1303, is the largest university in Italy. About 180,000 men and women study there.

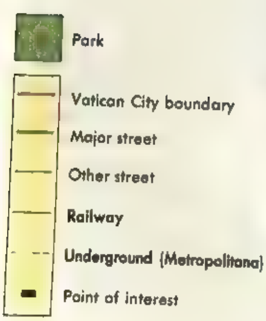


The Sports Palace was built for the 1960 Summer Olympic Games. It lies on the southwestern outskirts of the city.

years. The City Council elects one member of its group as mayor. The council also elects 18 of its members to the City Executive Committee. The mayor and the members of this committee all serve four-year terms. The mayor heads the committee as well as the general city administration. Fifteen departments direct the city's affairs, including health, markets, public works, and transportation.

Central Rome

This map shows the central area of Rome and locates many of its famous landmarks. The Tiber River flows through the area. Vatican City, the world's smallest independent country and the headquarters of the Roman Catholic Church, is surrounded by Rome.



The Roman Forum was the centre of Roman government.

The Pantheon was a temple dedicated to Roman gods.

The Arch of Constantine celebrated a military victory.

Trajan's Column stands 30 metres high.

Ancient Rome

Ara Pacis 4
Arch of Constantine 28
Arch of Septimius Severus 21
Basilica Julia 22
Basilica Ulpia 13
Baths of Caracalla 30
Baths of Constantine 10
Baths of Diocletian 3
Baths of Trajan 25
Catacombs of Sant' Agnese 1
Circus Maximus 29
Colosseum 27
Column of Marcus Aurelius 9
Curia 14
Domus Aurea 26
Forum of Augustus 17
Forum of Julius Caesar 15
Forum of Nerva 18
Forum of Trajan 16
Forum of Vespasian 19
Mausoleum of Augustus 5
Pantheon 8
Praetorian Camp 2
Roman Forum 23
Stadium 7
Temple of Saturn 20
Temple of Trajan 12
Tomb of Hadrian 6
Tomb of the Scipios 31
Trajan's Column 11
Via Sacra 24

The ancient city

Remains of the splendours of ancient Rome may be seen throughout the city, especially in an area east of the Tiber River. Since the 1800's, the Italian government has cleared the main sites of the ruins and surrounded them with trees and gardens. Thousands of tourists visit these attractions yearly.

Forums. The centres of ancient Roman life were open market places called *forums,* where public meetings were held. The Roman Forum, the most important one, was the centre of Roman government. Many important buildings and monuments stood there. Ruins in the Roman Forum include the *Curia* (Senate House), the triumphal Arch of Septimius Severus, the Temple of Saturn, and the Basilica Julia, an assembly hall.

Most streets of ancient Rome were narrow and crooked, but a few were wide and beautiful, with high arches and white marble buildings. The chief street, the *Via Sacra* (Sacred Way), crossed the Roman Forum. Victorious emperors and generals returning from war paraded over its lava pavement. See **Forum, Roman; Rome, Ancient** (picture: A triumphal procession).

Many Roman rulers built forums of their own. The ruins of five of these forums still stand—those of Augustus, Julius Caesar, Nerva, Trajan, and Vespasian. Trajan's Forum is the finest. Most of its buildings, including the Basilica Ulpia and the Temple of Trajan, are in ruins. But Trajan's Column, 30 metres tall, is almost whole. It has carvings of scenes from Trajan's wars. Nearby stand the Markets of Trajan, a large semicircle of three-storeyed shops. One of the shops has been rebuilt to show how it looked in ancient times. See **Trajan.**

The Colosseum, dedicated in A.D. 80, is one of the chief landmarks of Rome. In this huge, half-ruined amphitheatre, Romans watched trained fighters called *gladiators* battle each other or fight wild animals. The audiences also saw persecuted Christians killed by lions. See **Colosseum.**

Baths. Only wealthy Romans could afford to own private baths, but the city had many public ones. During the time of the emperors, the public baths became luxurious meeting places. They looked like great square-shaped swimming pools, and were surrounded by gardens, columned marble porches, and libraries. The bath buildings had facilities for warm and cold baths, steam baths, and massage.

The most splendid remains of baths are those of Caracalla and of Diocletian. The Baths of Caracalla, which date from the early A.D. 200's, are especially impressive. They were decorated with precious marble, statues, and *mosaics* (pictures formed out of multiple pieces of coloured glass, stone, or wood). Few of these decorations remain. But many tourists visit the ruins each year for their history and architecture. The Baths of Diocletian, completed in the early A.D. 300's, were the largest of all Roman baths. They could serve 3,000 people at a time. Most of the site has been built over, but some rooms can still be seen.

The catacombs were systems of underground passages and rooms used as Christian burial places and chapels. The early Christians dug them from the A.D. 100's to the early 400's, and hid there during periods of persecution. The catacombs are decorated with paintings on walls and ceilings, and Christian symbols. The most famous catacombs include those of San Callisto, San Sebastiano, and Sant' Agnese. See **Catacombs.**

Other remains. The Pantheon is the best preserved of all the remains of ancient Rome. The Romans built it as a temple in honour of all their gods (see **Pantheon**). The triple Arch of Constantine, built about A.D. 315, also is well preserved. It includes three connected arches, side by side, richly decorated with sculpture.

The ruins of the *Domus Aurea* (Golden House) are in a popular public park. This building was the palace of the Emperor Nero. The ruins, which lie mainly underground, occupy a large area. Paintings cover some of the walls. The well-preserved Column of Marcus Aurelius, built during the A.D. 100's, honours Roman victories in battle. It has carvings of war scenes. Stairs inside the hollow marble column lead to the top, where a statue of Saint Paul has stood since 1589.

The Mausoleum of Augustus, begun about 28 B.C., is the tomb of Augustus and the principal members of his family. Augustus, the first Roman emperor, built the nearby *Ara Pacis* (Altar of Peace) after establishing the *Pax Romana* (Roman Peace), which lasted 200 years. These buildings stood on the *Campus Martius* (Field of Mars), which had been used for military training. During the A.D. 200's, barbarian tribes attacked the empire, and Rome built the Aurelian Wall and other walls for defence. Many parts of these walls are still standing.

The Colosseum was a huge amphitheatre.

The catacombs were used as Christian burial places.

Early days. A legend says that Rome was founded by twin brothers in 753 B.C. For an account of this story, see **Romulus and Remus.** Rome expanded, and became the supreme power of the Western world. For the history of Rome until the fall of the West Roman Empire in A.D. 476, see **Rome, Ancient** (History).

After Rome fell to Germanic tribes, most of the once-splendid city became an unhealthy area of marshes. In the mid-500's, Emperor Justinian I of the Byzantine Empire drove the Ostrogoths from Rome. He reestablished Roman rule of the city as a Byzantine territory, but the decay of Rome continued. See **Byzantine Empire.**

Rome had far-reaching importance as the official centre of the Christian Church. During the 700's, the popes greatly increased their political power. When invading Lombards threatened Rome, Pope Stephen II asked for help from Pepin the Short, king of the Franks. Pepin saved Rome twice, and gave the city and nearby lands to the pope in 756. Pepin's son Charlemagne later expanded these *Papal States,* as they were called. See **Papal States; Pepin the Short.**

Feudal times and the Renaissance. For hundreds of years after the 800's, Rome was torn by struggles among kings and princes. Various European rulers tried to control the powerful popes, especially by influencing papal elections. In 1305, through the efforts of King Philip IV of France, a French archbishop was elected pope. The new pope, Clement V, moved his court to Avignon, France. It was returned to Rome in 1377. See **Pope** (The troubles of the papacy).

During this period, Cola di Rienzi, an Italian patriot, rebelled against the nobles. He established a democratic republic in 1347. But Rienzi soon became cruel and greedy for power, and was later killed in a riot.

Rome became one of the most splendid cities of the Renaissance. In 1527, raiding German and Spanish troops destroyed or stole many of the city's treasures, and killed thousands of Romans. Soon afterward, the job of rebuilding Rome began. During the rest of the 1500's and the 1600's, the popes built hundreds of magnificent buildings. They appointed the finest painters and sculptors, including Michelangelo, to design and decorate the structures.

The 1800's. In 1798, after Napoleon conquered the Italian Peninsula, the victorious French troops entered Rome. Napoleon ended the pope's political power in 1809. He made the Papal States a part of his empire. Napoleon also declared Rome to be the second city of his

A map of Rome shows the city's layout during the 1500's. Some of the 20 hills surrounding Rome rise in the background. The Tiber River flows through the city. St. Peter's Church stands on what was then the city's southwestern edge.

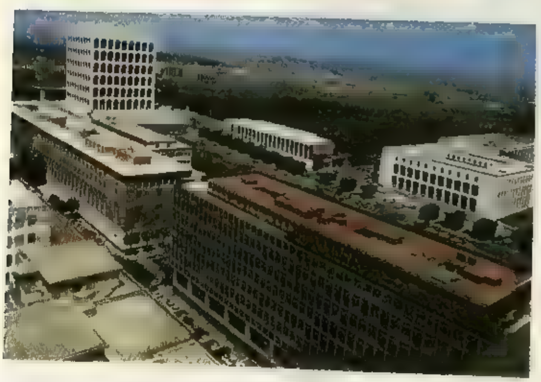
empire, after Paris. Pope Pius VII fought these changes, and Napoleon had him jailed. After Napoleon's defeat, the Papal States were returned to the pope in 1815.

During the early 1800's, movements for unity and freedom from foreign rule swept the Italian peninsula. But the popes opposed these movements. In 1848, revolutionaries made Rome a republic, and Pope Pius IX fled the city. French troops captured Rome in 1849, and restored the pope to power the next year.

In 1861, when Victor Emmanuel II became king of a united Italy, Rome was not yet a part of the new kingdom. Italian volunteers tried to take Rome in 1867, but French defenders stopped them. In 1870, after the French had left, Victor Emmanuel entered the city almost without bloodshed. He ended the pope's political power, and made Rome his capital in 1871. In protest, Pius IX shut himself up in the Vatican and refused to deal with the government. Succeeding popes followed the same policy until 1929. That year, Vatican City was made an independent state, and Roman Catholic Church officials recognized Rome as Italy's capital.

The 1900's have been a period of widespread construction in Rome. New buildings and roads have been built, and the city has restored many ancient buildings and monuments. During the 1920's and 1930's, the Fascist dictator Benito Mussolini promoted much poorly planned construction. It has led to severe traffic jams and other city problems today. Mussolini completed a new University of Rome campus in 1935, and began work on a huge central railway station in 1938. But construction was halted by World War II (1939-1945). Rome suffered little damage during the war. Neither side wanted to endanger the life of Pope Pius XII, who was in Vatican City. The central railway station was completed in 1950 according to improved new plans.

In 1938, Mussolini began building the *Esposizione Universale di Roma* (Universal Exhibition of Rome, or E.U.R.). This world's fair was to have opened in 1942, and plans called for its buildings to form a government centre later. The construction was interrupted by the war, and was resumed in 1951. This E.U.R. project included government and private office buildings, and blocks of flats, museums, and restaurants. In 1955, Rome's underground system linked the 435-hectare E.U.R. with the new railway station. Some of the 1960 Summer Olympic Games were held near the E.U.R. in the city's new Sports Palace. The E.U.R. was completed in 1976. Many large companies and government agencies operate there. In the early 1980's, Rome's city government adopted a long-term plan to restore many of Rome's ruins. By the late 1980's, several important monuments, including Trajan's Column and the Arch of Constantine, had been restored.



A huge complex called the *Esposizione Universale di Roma* (Universal Exhibition of Rome, or E.U.R.) includes numerous modern buildings. Many large companies and government agencies have their offices in the E.U.R.

The monument to Victor Emmanuel II, the first king of a united Italy (1861-1878), was completed in 1911.

Study aids

Related articles in *World Book* include:

Catacombs
City (picture)
Colosseum
Forum, Roman
Garibaldi, Giuseppe
Italy
Mazzini, Giuseppe
Michelangelo
Pantheon
Papal States
Pope
Rienzi, Cola di
Rome, Ancient
Romulus and Remus
Saint Peter's Church
Sistine Chapel
Tiber River
Vatican City

Outline

I. **The city today**
   - A. Parks and gardens
   - B. Music and theatre
   - C. Museums and art galleries
   - D. Churches, palaces, and fountains
   - E. Schools
   - F. Sports
   - G. Economy
   - H. Government

II. **The ancient city**
   - A. Forums
   - B. The Colosseum
   - C. Baths
   - D. The catacombs
   - E. Other remains

III. **History**

Questions

Why is Rome called the *Eternal City*? On how many hills was Rome built?
Where were public meetings held in ancient Rome?
What is the largest church in Europe?
What is Rome's most popular sport?
What great painter decorated the Sistine Chapel?
How did the Via del Corso get its name?
Between which two points does Rome's underground run?
What were the catacombs? What were they used for?
What is the legend of the Fountain of Trevi?

A triumphal procession paraded through the Roman Forum, the chief public square of ancient Rome, when a victorious general returned from war. The general rode in a chariot followed by his army. Before him marched trumpeters and Roman senators and other high government officials.

Ancient Rome

Rome, Ancient. The story of ancient Rome is a tale of how a small community of shepherds in central Italy grew to become one of the greatest empires in history—and then collapsed. According to Roman legend, the city of Rome was founded in 753 B.C. By 275 B.C., it controlled most of the Italian Peninsula. At its peak, in the A.D. 100's, the Roman Empire covered about half of Europe, much of the Middle East, and the north coast of Africa. The empire then began to crumble, partly because it was too big for Rome to govern. In A.D. 476, warlike Germanic tribes overthrew the last Roman emperor.

The millions of people who lived in the Roman Empire spoke many languages and followed many different customs and religions. But the Roman Empire bound them together under a common system of law and government. This remarkable achievement has aroused interest and admiration from ancient times right up to the present day.

Ancient Rome had enormous influence on the development of Western civilization because the empire was so vast and lasted so long. The language of the ancient Romans, Latin, became the basis of French, Italian, Spanish, and the other Romance languages. Roman law provided the foundation for the legal systems of most of the countries in Western Europe and Latin America. Roman principles of justice and the Roman political system contributed to the building of governments in many countries. Roman roads, bridges, and aqueducts—some of which are still used—served as models for engineers in later ages.

This article provides a broad overview of the people, achievements, government, and history of ancient Rome. Many separate *World Book* articles have detailed information. For a list of these articles, see the *Related articles* at the end of the article.

The Roman world

Land. Ancient Rome arose on seven wooded hills along the Tiber River in central Italy. The Tiber provided a convenient route to the sea, which lay about 24 kilometres to the west. But Rome was far enough from the sea to escape raids by pirates. Rome's hills were very steep, and so the city could be easily defended against enemy attacks. Fertile soil and excellent building materials lay nearby.

The Italian Peninsula gradually came under Roman rule. The peninsula jutted far out into the Mediterranean Sea. Italy thus occupied a central position among the lands bordering the Mediterranean. To the north, the Alps helped protect Italy against invaders from central Europe. But mountain passes let through a slow stream of settlers, who were attracted by Italy's mild climate and fertile soil. In time, the steadily growing population provided the soldiers Rome needed for expansion.

Roman rule slowly spread over all the lands bordering the Mediterranean Sea. The Romans called the Mediterranean *Mare Nostrum* (Our Sea) or *Mare Internum* (Inland Sea). At its greatest size, in the A.D. 100's, the

Roman Empire also extended as far north as the British Isles and as far east as the Persian Gulf.

The Roman Empire had many natural resources. They included fertile grainfields in Sicily and northern Africa, rich mineral deposits in Spain and Britain, and marble quarries in Greece. There were also thick forests in Asia Minor and thriving vineyards and olive orchards in Gaul (now France, Belgium, and part of Germany).

People. The Roman Empire probably had from 50 to 70 million people at its height. Of that number, nearly 1 million people lived in Rome, and from 5 to 6 million lived in the rest of Italy.

The peoples of the Roman Empire differed greatly in their customs and spoke many languages. Peoples in Mesopotamia, Palestine, Egypt, and Greece had cultures far older than that of Rome. But many peoples in Britain, Germany, and Gaul were introduced to more advanced civilization by the Romans. Throughout the empire, government officials and members of the upper class spoke Latin and Greek. But most conquered peoples continued to use their native languages. For example, people spoke Celtic in Gaul and Britain, Berber in northern Africa, and Aramaic in Syria and Palestine.

The people of ancient Rome were divided into various social classes. Very few Romans belonged to the upper classes. Members of the Senate and their families made up the most powerful upper-class group. Most people belonged to the lower classes and had little social standing. Within this group, Romans distinguished between citizens and slaves. Citizens included small farmers, city workers, and soldiers. Most slaves were people captured in warfare. In time, slaves could buy or be given their freedom and become *liberti* (freedmen) and eventually citizens.

As the Roman world expanded, a new social class became important. This class consisted of prosperous landowners and business people, who were called *equites*. Under the Roman emperors, equites held important government positions and helped run the empire's civil service.

Roman citizenship was eventually granted to most peoples of the empire. Citizenship meant protection under Roman law. The privilege of citizenship promoted loyalty to the empire and gave peoples of all classes and all regions a greater stake in its success.

Life of the people

City life. Rome was the capital and the largest city of the Roman Empire. It had almost a million inhabitants at its height. No earlier city had achieved such size and splendour. Alexandria, in Egypt, was the empire's second largest city. It had about 750,000 people. Other important cities included Antioch in Syria and Constantinople (now Istanbul, Turkey).

Cities in the Roman Empire served as centres of trade and culture. Roman engineers planned cities carefully. They located public buildings conveniently and provided for sewerage and water supply systems. Emperors or wealthy individuals paid for the construction of such large public buildings as baths, sports arenas, and theatres. At the heart of a Roman city lay the *forum*—a large open space surrounded by markets, government buildings, and temples. Rich and poor mingled in the bustling forum and at the baths, theatres, and arenas.

Rural life. The first Romans were shepherds and farmers. In early Rome, farmers who worked their own land formed the backbone of the Roman army. They planted their crops in spring and harvested them in autumn. During the summer, they fought in the army.

Rural life changed after Rome began to expand its territory. Many farmers were sent to fight wars abroad for long periods, and so they had to sell their land. Wealthy Romans then built up large estates on which they raised crops and livestock to sell for a profit. They bought slaves to work for them and also rented land to tenant farmers. For most farmers, life was hard. But they could look forward to regular festivals, such as those at planting and at harvest, which provided athletic games and other entertainment.

Family life. The head of a Roman household was the *paterfamilias* (father of the family). He had total power over all members of his household. The paterfamilias even had the power to sell his children into slavery or have them killed. As long as his father lived, a son could not own property or have legal authority over his own children. Many households were therefore large and included married sons and their families.

Children in ancient Rome enjoyed many of the same kinds of toys and games that delight children today. For example, they had dolls, carts, hobbyhorses, and board games. They also had dogs, cats, and other pets. But Roman children took on adult responsibilities sooner than most children do today. In poor rural families, children had to work in the fields. In wealthier families, children married early. Most boys married when they were 15 to 18 years old, and most girls when they were 13 or 14. Parents selected marriage partners for their children, who had little say in the matter. Many marriages were arranged for the economic or political benefits they would bring to the families.

Education. Ancient Rome had no state schools. Children received their earliest education at home under their parents' supervision. From the age of 6 or 7 until about 10 or 11, most boys and some girls attended a private school or studied at home. They learned reading, writing, and arithmetic. Slaves taught the children in many homes. Some slaves, especially those from Greece, had more education than their masters.

Most Roman children who received further education came from wealthy families. Until they were 14, they studied mainly Latin and Greek grammar and literature. They also studied mathematics, music, and astronomy.

Higher education in ancient Rome meant the study of *rhetoric*—that is, the art of public speaking and persuasion. Only upper-class Romans who planned a career in law or politics studied rhetoric. Training in rhetoric provided the skills needed to argue cases before law courts or to debate issues in the Roman Senate. To improve their abilities as public speakers, students might also read philosophy and history. Few women studied rhetoric because women were forbidden to enter politics.

Religion. The earliest Romans believed that gods and goddesses had power over agriculture and all aspects of daily life. For example, Ceres was the goddess of the harvest, the goddess Vesta guarded the hearth fire, and the god Janus stood watch at the door. Gods called *lares* and *penates* guarded both the community and the home. Even Jupiter, who later became the supreme

Roman god, was first worshipped as a sky god with power over the weather.

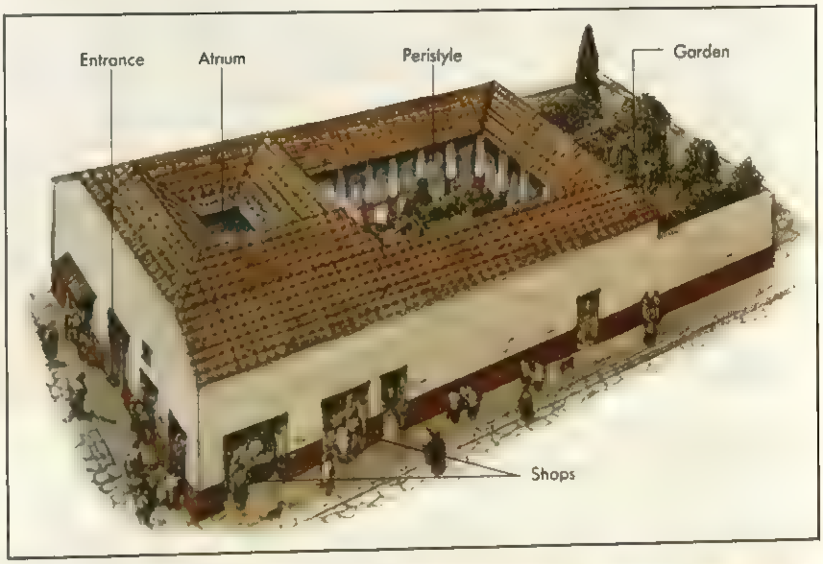
During the 300's B.C., the Romans came into increasing contact with Greek ideas. They then began to worship Greek gods and goddesses. They gave them Roman names and built temples and shrines in their honour. The government controlled religion. Priests were government officials, who were either elected or appointed. They performed public ceremonies to win the favour of the gods and goddesses for the state.

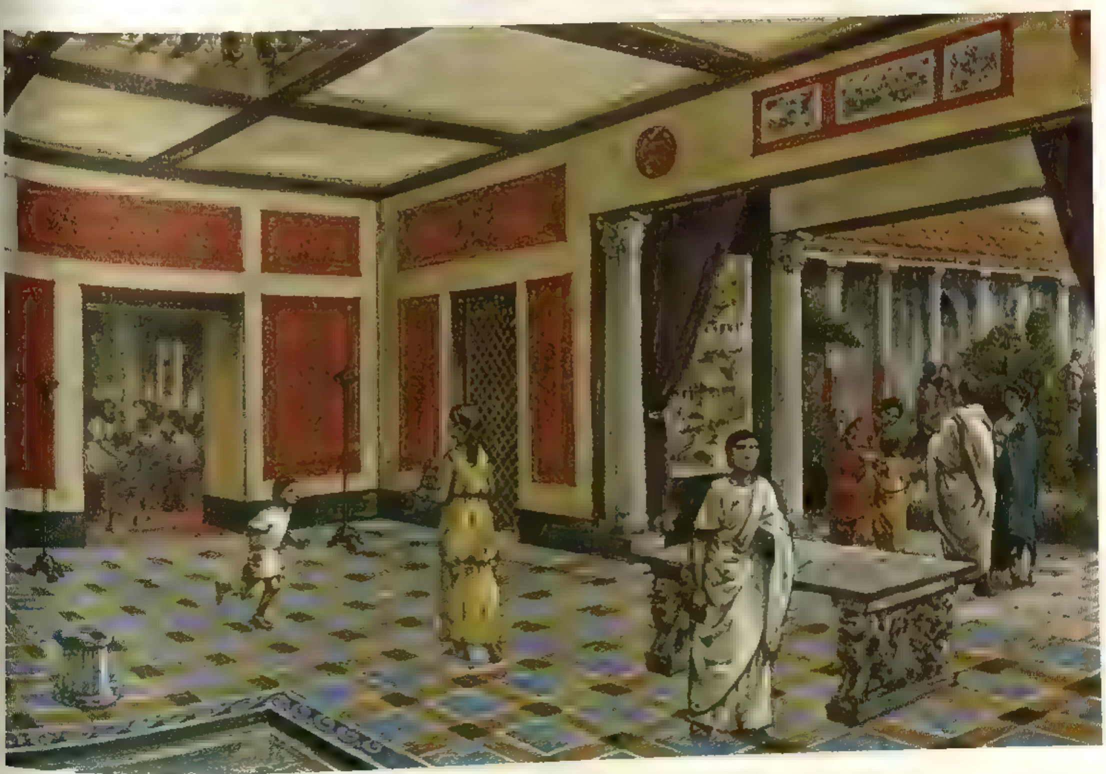
By A.D. 100, many Romans had lost interest in their religion. They became attracted to the religions of the Middle East, which appealed strongly to the emotions. Some of these religions promised salvation and happiness after death. Christianity, one of the Middle Eastern religions, gained many followers.

Food, clothing, and shelter. The Romans began their day at sunrise. Daylight was precious because the oil lamps the people used after dark gave off little light. Breakfast was usually a light meal of bread and cheese.

A Roman house

The illustration on the right shows a typical large house of a wealthy Roman. A courtyard called an *atrium* served as a reception room. An opening in the atrium roof let in air and light. Other rooms opened onto the atrium. Brightly coloured wallpaintings and marble floor tiles decorated some atriums, such as the one below. A second courtyard, called a *peristyle*, was planted with trees, flowers, and shrubs. It might also have had a fishpond and a fountain. Fruits and vegetables were grown in a walled garden at the rear of the house. In some houses, small shops faced the street.





Trained warriors called *gladiators* battled to the death before huge crowds in ancient Rome. Some gladiators wore armour and carried a sword and a shield. Others used only a net and a spear or trident. They tried to entangle their opponent in the net before driving in the spear.

Most Romans ate lunch just before midday. For wealthy Romans, it consisted of meat or fish and olives or fruit. Dinner, the main meal, began in the late afternoon so that it could end before sunset.

Wealthy Romans feasted on several courses at dinner. Their first course might include eggs, vegetables, and shellfish. The main course featured meat, fish, or fowl. For dessert, they usually ate honey-sweetened cakes and fruit. Poorer Romans ate much simpler meals. For example, their dinners consisted mainly of porridge and bread plus some olives, fruit, or cheese.

The Romans wore simple clothes made of wool or linen. The main garment for both men and women was a gown called a *tunic.* It hung to the knees or below. The tunic also served as nightwear. Over this, men wore a *toga* and women wore a *palla.* Both garments resembled a large sheet, which was draped around the body. Men almost always wore white clothing, though the toga of upper-class Romans had a purple border. Women's clothing might be dyed various colours.

In the cities, most Romans lived in crowded blocks of flats from three to five storeys high. Only rich Romans could afford houses. Their houses were built around a courtyard called an *atrium.* Most rooms surrounding the atrium were small and windowless. But the atrium was spacious and had a roof opening that let in light and air. Large houses had a second courtyard, called a *peristyle,* which served as a garden. Poor people in farm areas lived in huts made of sun-dried bricks.

Recreation. The Romans observed many holidays. Most holidays were religious festivals in honour of gods and goddesses. Holidays had become so numerous by the A.D. 100's that Emperor Marcus Aurelius limited them to 135 days a year. On many holidays, the emperor or wealthy government officials sponsored free, public entertainments in outdoor arenas called *amphitheatres.*

The most famous amphitheatre in the city of Rome, the Colosseum, seated about 50,000 spectators. Many of the entertainments held there were violent and bloody. For example, trained warriors called *gladiators* fought one another to the death. Most gladiators were slaves, prisoners of war, or condemned criminals. In other events, armed men fought wild animals, or starving beasts attacked condemned criminals.

Chariot races drew huge crowds in ancient Rome. The races took place in a long, oval arena called a *circus.* The Circus Maximus, the largest arena in Rome, held about 250,000 people. Skilled charioteers became popular heroes. Many Romans bet on their favourites.

Three theatres in Rome staged comedies and serious dramas by Greek and Roman authors. But most Romans preferred *mimes* (short plays about everyday life) or *pantomimes* (stories told through music and dancing).

Roman emperors built lavish public baths decorated in marble and gold to encourage daily exercise and bathing. Bathers moved through steam rooms and indoor pools of warm, hot, and cold water. Romans also visited the baths for recreation and to meet friends. Gymnasiums, exercise grounds, gardens, sitting rooms, and libraries surrounded the bathing areas.

Work of the people

Agriculture. About 90 per cent of the people of the Roman world lived by farming. The Romans under-

stood the need to rotate crops. They also knew that by leaving half of every field unplanted each year the soil would be enriched for a crop the next year. However, few small landowners could afford that practice.

In fertile valleys north and south of Rome, farmers grew such grains as wheat, rye, and barley. On hillsides and in less fertile soil, they planted olive groves and vineyards and grazed sheep and goats. Roman farmers also raised pigs, cattle, and poultry. As the empire expanded, farms in Gaul, Spain, and northern Africa supplied Rome with many agricultural products.

Manufacturing. The city of Rome never became a manufacturing centre in ancient times. It imported most of its manufactured goods. Other Italian communities supplied the capital with such products as pottery, glassware, weapons, tools, and textiles. They also made the bricks and lead pipes needed by Rome's booming construction industry. As the empire expanded, important manufacturing centres developed outside Italy. They served local markets and exported goods to Rome.

Mining was one of ancient Rome's most important activities. The empire's great building projects required large supplies of marble and other materials. Marble came from Greece and northern Italy. Italy also had copper and rich deposits of iron ore. Most of the empire's gold and silver came from Spain. Mines in Britain produced lead and tin. Work in the mines was hard and unhealthy. The Romans forced slaves, condemned criminals, and prisoners of war to work in the mines.

Trade thrived as the Roman Empire expanded. Huge sailing ships carried cargo from one end of the Mediterranean Sea to the other. Carts and wagons hauled goods over the empire's vast network of roads.

The city of Rome's chief imports included foods, raw materials, and manufactured goods. The Italian Peninsula exported wine and olive oil. The Romans also traded with lands outside the empire. For example, they imported silk from China, spices and precious gems from India, and ivory from Africa. The Roman government issued coins of gold, silver, copper, and bronze and controlled the money supply, making trade easier.

Transportation and communication. An excellent system of roads crisscrossed the Roman Empire. The roads covered about 80,000 kilometres and helped hold the empire together. The Roman army built the roads to speed troop movements. The roads also promoted trade and communication. The highly organized Roman postal system depended on the road system. The straight, smooth Roman roads were the finest of the time.

The Romans built up the largest fleet of cargo ships of ancient times. Their ships travelled to all ports on the Mediterranean Sea and on such large rivers as the Rhine, Danube, and Nile.

In Rome the government published a bulletin called *Acta Diurna* (Daily Events). The bulletin was posted in the city's public places and may have taken the form of words painted on wood. The *Acta Diurna* reported on the events of the day, including Senate business. People made copies of the *Acta Diurna* and circulated them throughout the empire like a modern newspaper.

Arts and sciences

Architecture and engineering. The ancient Romans adopted the basic forms of Greek architecture. These forms included the temple surrounded by columns and the covered walkway known as a *portico*. The Romans also created new kinds of structures, such as public baths and amphitheatres, that held many people. In gen-

Crowded shops occupied the ground floors of many buildings in ancient Rome. At the market, women did their shopping, men drank wine with friends, and craft workers sold their handiwork. Public fountains in the narrow streets provided water for Roman homes.

Aqueduct construction, *above,* was one of the peacetime activities of the Roman army. Roman aqueducts carried water long distances from rivers and mountain springs. The water ran in a channel along the top of an aqueduct. Roman soldiers also built roads, bridges, tunnels, and walls.

eral, the Romans designed larger and grander buildings than did the Greeks.

Two achievements of Roman engineering made the large Roman buildings possible. They were the arch and concrete. Arches supported such structures as bridges and the aqueducts that carried water to Roman cities. Arched roofs called *vaults* spanned vast interior spaces of buildings. Vaults eliminated the need for columns to hold up roofs. Although the Romans did not invent the arch, they were the first people to realize its possibilities. Concrete, which the Romans did invent, provided a strong building material for walls and vaults.

Sculpture and painting. Roman sculptors and painters borrowed from Greek art and native Italian traditions. Their works thus reflected both the lifelike but idealized human figures of Greek art and the more realistic aspects of native Italian art.

Roman sculptors created realistic portraits that revealed individual personalities. They also illustrated historical events by means of carvings on large public monuments. For example, the richly decorated Ara Pacis (Altar of Peace) celebrated the peace brought to the empire by Emperor Augustus. Carvings on tall columns and triumphal arches told of military campaigns.

Large wallpaintings decorated the houses of well-to-do Romans. Such paintings showed garden landscapes, events from Roman mythology, and scenes of everyday life. The richly coloured, carefully created paintings made rooms in houses seem larger and brighter.

Literature of ancient Rome was greatly influenced by Greek poetry and drama. The Roman poets and dramatists Naevius and Ennius and the playwrights Terence and Plautus adapted Greek forms to Roman audiences. Caesar and Sallust based their historical writings on Greek models. Powerful and original works were produced by Rome's greatest poets—Catullus, Lucretius, Ovid, and Virgil—and by its most brilliant historian, Tacitus. Other important works of Latin literature include the speeches of Cicero, the satires of Horace and Juvenal, and the letters of Cicero and Pliny the Younger.

Science. The ancient Romans made few scientific discoveries. But the work of Greek scientists flourished under Roman rule. The Greek geographer Strabo travelled widely in the Roman Empire and wrote careful descriptions of what he saw. Ptolemy, a Greek astronomer living in Egypt, developed a theory of the universe that was accepted for nearly 1,500 years. Galen, a Greek doctor, proposed important medical theories based on scientific experiments. The Romans themselves assembled important collections of scientific information. For example, Pliny the Elder compiled a 37-volume encyclopedia entitled *Historia Naturalis* (Natural History).

Government

At first, a series of kings ruled ancient Rome. Each king was advised by a Senate made up of the heads of Rome's leading families. Citizens met in assemblies to vote on the decisions of king and Senate.

The Roman Republic was established in 509 B.C., after Roman nobles overthrew the king. The new government kept many features of the earlier system, including the Senate and citizen assemblies. Two elected officials called *consuls* headed the government. The consuls shared power, but either consul could veto the actions of the other. A consul served for only a year.

The Senate was the most powerful government body of the Roman Republic. The Senate conducted foreign policy, passed *decrees* (official orders), and handled the government's finances. Senators, unlike consuls, served

for life. At first, all senators were *patricians*—that is, members of Rome's oldest and richest families. Patricians controlled not only the Senate but also the assembly that elected the consuls and other important officials. All the rest of Rome's citizens, who were called *plebeians,* had little political influence.

To obtain political rights, plebeians formed their own assembly, the *Concilium Plebis,* and elected leaders called *tribunes.* Largely through the work of the tribunes, plebeians gradually gained the same political rights as the patricians. In time, a new and larger assembly, the *Comitia Tributa,* developed. It represented both patricians and plebeians, but plebeians largely controlled the assembly.

The Roman Republic lasted nearly 500 years, until 27 B.C. It combined strong heads of state, a respected Senate of senior statesmen, and assemblies where the people could be heard. For centuries afterward, historians and political scientists viewed the Roman Republic as a model of balanced government.

The Roman Empire was established in 27 B.C., after the republic had been destroyed by 20 years of civil war. The empire lasted until Rome fell in A.D. 476. During that time, emperors held supreme authority. The republican institutions of government were kept. But emperors nominated the consuls and appointed new senators. The citizen assemblies had little power. Emperors headed the army and directed the making of laws. They relied more on their own advisers than on the Senate. A vast civil service handled the empire's day-to-day business.

The law. The Romans published their first known code of law about 450 B.C. This code, called the Laws of the Twelve Tables, set down accepted practices in written form. Roman law remained flexible. It depended on the interpretations of skilled lawyers and judges.

Through the years, a general set of legal principles developed that governed all the various peoples living under Roman rule. Roman lawyers called this set of principles the *jus gentium* (law of nations). The jus gentium was based on common-sense notions of fairness. It took into account local customs and practices.

The army. Under the Roman Republic, the army was made up only of citizens who owned land. The Romans felt that property owners had a greater stake in the republic than did landless people and would therefore defend it better.

As Rome began to fight wars overseas, it required more soldiers, and they had to serve for longer periods. The government abolished the property requirement in 107 B.C. and opened the army to volunteers. The army then offered a long-term career for many Romans. In time, more and more soldiers were recruited from the provinces. By about 20 B.C., some 300,000 men served in the Roman army. The number of soldiers changed little thereafter. Most soldiers were professionals, whose training and discipline made the Roman army one of the greatest fighting forces in history.

Roman soldiers did not only fight. They also built roads, aqueducts, walls, and tunnels. After Rome reached its greatest size, the army's main task was to defend the empire's frontiers. Many troops were thus stationed along the Rhine and Danube rivers. Other important army posts stood in Egypt, Syria, and Britain.

History

Beginnings. Historians know little about the early days of ancient Rome. According to Roman legend, twin brothers, Romulus and Remus, established a settlement in 753 B.C. on the Palatine Hill, one of Rome's hills overlooking the Tiber River. Greek legend told of the Trojan hero Aeneas, who founded a settlement in central Italy after the destruction of Troy by the Greeks in the Trojan War. Some versions combined the two myths and made Romulus and Remus descendants of Aeneas.

The first known settlers of ancient Rome lived on the Palatine Hill about 1000 B.C. Most historians believe that these settlers were a people called Latins. Latins also inhabited many neighbouring towns in Latium, the region surrounding Rome. A succession of kings ruled the Latins of Rome.

About 600 B.C., Rome and other towns in Latium came under the control of the Etruscans, a people who lived north of Latium. The Etruscans had the most advanced civilization in Italy. They built roads, temples, and public buildings in Rome. They also promoted trade and introduced the idea of the citizen assembly. Under Etruscan rule, Rome grew from a village of farmers and shepherds into a prosperous city. The city became so powerful that the people were able to drive out the Etruscans.

The early republic. The Roman Republic was established in 509 B.C., after the overthrow of the monarchy. However, the institutions of republican government developed gradually through a long struggle between the landowning upper class—that is, the patricians—and all the other citizens, the plebeians. At first, only patricians held political office, served as priests, and interpreted Roman law. Plebeians had few political rights and often received unfair treatment from judges.

Plebeians fought for political rights during the 400's and 300's B.C. By 287 B.C., they had won the right to hold any public or religious office and had gained equality under the law. But vast differences in wealth and social position still separated most plebeians from patricians.

Meanwhile, Rome was slowly gaining military control over the rest of the Italian Peninsula. In 493 B.C., Rome entered an alliance with the Latin League, a federation of cities of Latium. Rome had become the largest city in Latium by 396 B.C. and thereafter used the league's resources to fight wars with its neighbours. Rome offered protection and certain privileges of Roman citizenship to the cities it conquered. In return, the conquered cities supplied the Roman army with soldiers.

During the 300's B.C., Rome won victories over the Etruscans. Rome also defeated the Gauls, who had invaded Italy from the north and burned Rome in 390 B.C. In 338 B.C., Rome overpowered and disbanded the Latin League. In 290 B.C., the Romans conquered the Samnites, a mountain people who lived south of Rome. Rome ruled most of the Italian Peninsula by 275 B.C., after defeating the Greek colony of Tarentum in southern Italy, and the Greek king Pyrrhus, Tarentum's champion.

Expansion overseas made Rome a mighty empire during the 200's and 100's B.C. Rome came into conflict first with Carthage, a sea power and trading centre on the coast of northern Africa. Rome and Carthage fought for mastery of the Mediterranean Sea in three struggles

Hadrians Wall was built for defence across northern Britain by Emperor Hadrian
Britain
London
Atlantic Ocean
The Roman Army conquered vast territories for the empire and defended its frontiers
Germanic Lands
Rhine River
Danube River
Gaul
Farms in Gaul supplied Rome with wine and food Gaul also produced pottery and glassware.
Roman Law was based on common-sense notions of fairness It spread throughout the empire
Agriculture provided a living for about 90 per cent of the people in the Roman Empire.
Illyria
Spain
Huge Aqueducts supplied about 200 cities in the Roman Empire with water.
Corsica
Italy
Rome
Sardinia
Chariot Racing was a popular entertainment in ancient Rome People bet on their favourite drivers.
Sicily
Mediterranean Sea
Carthage
Mauretania
Roman Warships, which were propelled by oars and sails, ruled the Mediterranean Sea
Timgad, like many other Roman cities, had an orderly plan and was originally built as an army camp.
Wild Animals caught in Africa were shipped to Rome to fight people in bloody public games.

The Roman world

Roman rule gradually spread over all the lands bordering the Mediterranean Sea. At the time of its greatest size, the Roman Empire also stretched from Britain in the north to Mesopotamia in the east. The peoples who lived in the Roman Empire spoke many languages and followed different customs. Yet the Roman Empire united them under a common system of law and government.

called the Punic Wars. In the First Punic War (264-241 B.C.), Rome conquered Sicily, an island off the tip of Italy, and made it the first Roman province. Rome also seized two other Mediterranean islands—Sardinia and Corsica. In the Second Punic War (218-201 B.C.), the brilliant Carthaginian general Hannibal led his army over the Alps and invaded Italy. Although Hannibal won several key battles, Roman manpower and endurance eventually wore him down. Under the leadership of Scipio, the Roman forces defeated Hannibal in 202 B.C. In the Third Punic War (149-146 B.C.), Rome destroyed Carthage. These victories brought the Mediterranean coasts of Spain and Africa under Roman control.

After the Second Punic War, Rome began to expand in the east. At first, Rome acted to protect its allies along Italy's east coast from pirate raids. But it soon became involved in conflicts between Greece and Macedonia. Macedonia, which lay north of Greece, had conquered the Greeks in 338 B.C. Rome posed as the liberator of the Greeks. But by the 140's B.C., it had taken control of Greece and Macedonia. In 133 B.C., King Attalus III of Pergamum, a Roman ally, died and left his kingdom (now part of Turkey) to Rome.

Two reasons help explain Rome's remarkable expansion overseas. First, Rome built an alliance of cities in Italy that supplied the army with enormous manpower. Second, pride in their military power and government institutions gave the Romans great confidence in their superiority and in the justness of their cause.

Breakdown of the republic. Although the Romans had triumphed overseas, they faced growing discontent at home. Wealthy Romans profited from the tax revenues, slaves, and looted property that poured into Rome from defeated lands. But unemployment rose as plantations worked by slaves drove out the small farmers, and the gap between rich and poor widened. In 133 and 123 B.C., two Roman tribunes tried to help the poor. Tiberius Gracchus and his brother, Gaius Gracchus, promoted a programme to distribute state-owned land to the poor. But the majority of the Senate opposed them, and both brothers were assassinated.

Conflicts among leaders caused upheaval in the Roman Republic during its last 100 years. Revolts by Rome's Italian allies, a war in Asia, and unrest at home weakened the republic. In 82 B.C., the Roman general Lucius Sulla became dictator. Sulla restored stability to the government and strengthened the Senate by bringing in new leaders. Sulla retired in 79 B.C., but he had given Rome a taste of one-man rule.

In the 60's B.C., Rome again began to expand overseas. The Roman general Pompey conquered eastern Turkey, Syria, and Palestine. He returned to Rome a popular hero, but the Senate refused to recognize his victories. As a result, Pompey and two other Roman leaders—Julius Caesar and Marcus Crassus—formed a three-man political alliance called the First Triumvirate in 60 B.C. Crassus died in warfare in 53 B.C. Other Roman leaders then tried to split the two surviving members of the Triumvirate.

From 58 to 51 B.C., Caesar conquered Gaul, thereby adding the huge territory west of the Rhine River to the Roman world. Pompey and the Senate feared Caesar's power and ambition, and they ordered him to give up his command. But Caesar marched his troops across the Rubicon, a stream that separated Italy from Gaul, and invaded Italy in 49 B.C. In the civil war that followed, Caesar defeated Pompey and his followers. By 45 B.C., Caesar had become sole ruler of the Roman world. A group

Highlights in the history of ancient Rome

753 B.C. — According to legend, Romulus and Remus founded Rome.

509 B.C. — The Romans drove out the Etruscans and established a republic.

264-146 B.C. — Rome began its expansion overseas by defeating Carthage in three Punic Wars.

27 B.C. — Augustus became the first Roman emperor.

Bronze sculpture; Museo del Palazzo dei Conservatori, Rome

The legendary founders of Rome were twin brothers named Romulus and Remus. According to Roman mythology, a wolf nursed them as babies.

Tomb painting (500's B.C.) in Tarquinia, Italy

The Etruscan culture of central Italy influenced Rome during the 500's B.C. Under Etruscan rule, Rome grew from a village into a prosperous city.

Marble sculpture by an unknown artist; Uffizi Gallery, Florence, Italy

Cicero, the great Roman statesman and orator, supported Rome's republican government. But the Roman Republic ended soon after he died in 43 B.C.

of aristocrats who hoped to revive the Roman Republic assassinated him in 44 B.C.

Civil war again broke out after Caesar's death. In 43 B.C., Caesar's adopted son and heir, Octavian, formed the Second Triumvirate with two army officers, Mark Antony and Marcus Lepidus. Octavian and Antony defeated Caesar's enemies and soon pushed Lepidus aside. Octavian and Antony then fought each other for control of Rome. Antony sought the support of Cleopatra, queen of Egypt, and they fell in love. In 31 B.C., Octavian defeated the forces of Antony and Cleopatra in the Battle of Actium off the west coast of Greece. The next year, the Romans conquered Egypt and made it a Roman province.

After the defeat of Antony, Octavian was the unchallenged leader of the Roman world. In 27 B.C., he became the first Roman emperor and took the name Augustus, meaning *exalted.* In spite of his power, Augustus avoided the title of emperor. He preferred to be called *princeps,* meaning *first citizen.* Nearly 20 years of civil war had destroyed the republic. Only a strong central authority seemed able to govern the empire.

The height of the empire. The reign of Augustus marked the beginning of a long period of stability, which became known as the *Pax Romana* (Roman Peace). The Pax Romana lasted about 200 years. Augustus reestablished orderly government and the rule of law. The Senate, consuls, and tribunes still functioned, but Augustus had supreme power. He commanded the army, controlled the provinces, and filled the Senate with his supporters.

Augustus established strong defences along the frontiers of the Roman Empire and kept the provinces under control. He began to develop a civil service staffed by skilled administrators to help govern the empire. Trade flourished, and art and literature reached a high point during what has been called the *Augustan Age.*

Augustus died in A.D. 14. He had groomed his stepson Tiberius to succeed him, thereby preparing the way for a succession of emperors. Members of Augustus' family, known as the Julio-Claudians, ruled until A.D. 68. They were followed by the Flavian family, which reigned until A.D. 96. The Roman Empire reached its height of power and prosperity during the reign of the Antonines, from A.D. 96 to 180. The Antonine rulers—Nerva, Trajan, Hadrian, Antoninus Pius, and Marcus Aurelius—were noted for their wisdom and ability.

The Roman Empire grew relatively little after the reign of Augustus. In A.D. 43, Emperor Claudius invaded Britain. Trajan seized Dacia (now part of Hungary and Romania) in A.D. 106. The stable political and military situation encouraged Romans to invest in land. Small farms and large estates thrived. Roman roads made excellent communications possible. Roman emperors encouraged the founding of new towns and cities, even in remote areas. The civil service grew increasingly skilled at running the day-to-day business of the empire. Provincial governors usually served long terms and so gained familiarity with the territories they controlled.

The authority of the Roman emperors gradually grew stronger. An emperor's order overruled any act of the Senate. The Romans worshipped an emperor as a god after his death. Emperor worship provided a common base of loyalty among the empire's peoples, who otherwise observed many different religions and traditions.

In the eastern part of the Roman Empire, a new religion developed based on the teachings of Jesus Christ. Although the Romans crucified Jesus for treason in

A.D. 96-180 — The Roman Empire reached its height of power and prosperity.

A.D. 395 — The Roman Empire split into two parts—the West Roman Empire and the East Roman Empire.

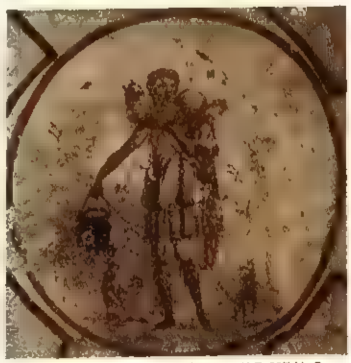
A.D. 476 — The last emperor of the West Roman Empire, Romulus Augustulus, was overthrown by a Germanic tribe.

Mosaic (A.D. 200's); Bardo Museum, Tunis, Tunisia

Latin literature flourished in the Age of Augustus, from 27 B.C. to A.D. 14. The poet Virgil, *seated,* wrote of Rome's creation in his great epic, the *Aeneid.*

Relief sculpture (A.D. 100's); The Louvre, Paris

The praetorians were soldiers who guarded the emperor. In time, the emperors grew removed from the people and were worshipped as gods after death.



Wallpainting (A.D. 200's) in Rome

Christianity spread rapidly in the Roman Empire, though Christians were often persecuted. Christians were granted freedom of worship in A.D. 313.

about A.D. 30. His followers spread Christianity throughout the empire. The Roman government took little notice of Christianity at first. Persecutions of Christians stemmed from local hostility rather than orders from Rome.

Growing disorder. Marcus Aurelius became emperor in A.D. 161. He defended the Roman Empire against attacks by Germanic tribes from the north and Parthians from the east. But growing disorder plagued the empire after his son, Emperor Commodus, died in 192. Many emperors seized power by force, and rival leaders fought for the throne. From 235 to 284, 60 men were proclaimed emperor. Most of the men were army commanders whose troops named them emperor.

The enormous size of the Roman Empire hastened its breakdown. A central authority in Rome could no longer hold the empire together. In addition, the struggles for power among Roman generals seriously weakened the empire's defences. The Goths, a Germanic people, invaded Roman territory many times during the 200's, and the Persians overran Mesopotamia and Syria.

Temporary recovery. Diocletian, a Roman general, was proclaimed emperor by his troops in 284. Diocletian realized that one man could no longer govern the empire. To restore order, he divided the provinces into smaller units. Each unit had its own government and army. He appointed a soldier named Maximian to be co-emperor and two deputies to succeed them. Maximian ruled the western part of the empire, and Diocletian ruled the eastern part. Diocletian's reforms temporarily halted the empire's collapse. But heavy taxes were needed to pay for the larger army and government.

Christians suffered severe persecution during the 200's. Many Romans blamed them for causing the evils of the time by having offended the traditional Roman gods. In 303, Diocletian forbade Christian worship.

Constantine I was named emperor of Rome's western provinces in 306. Diocletian's system of shared rule and succession quickly broke down as several men struggled for the throne. In 312, Constantine defeated his major rival after having had a vision promising victory if he fought under the sign of the cross. In 313, Constantine and Licinius, emperor of the eastern provinces, granted Christians freedom of worship. Constantine and Licinius ruled jointly until 324, when Constantine defeated his co-emperor in war. Constantine, who later became known as "the Great," moved his capital to Byzantium in 330 and renamed the city Constantinople.

Decline and fall. After Constantine died in 337, his three sons and two of his nephews fought for control of the Roman Empire. One of the nephews, Julian, became emperor in 361. Julian tried to check the spread of Christianity and restore the traditional Roman religion. But by the late 300's, Christianity had become the official religion of the empire. The empire was permanently split into the West Roman Empire and the East Roman Empire after Emperor Theodosius I died in 395.

The West Roman Empire grew steadily weaker. The Vandals, Visigoths, and other Germanic peoples invaded Spain, Gaul, and northern Africa. In 410, the Visigoths looted Rome. The fall of the empire is often dated 476. That year, the Germanic chieftain Odoacer forced Romulus Augustulus, the last ruler of the West Roman Empire, from the throne. Germanic chieftains had already begun to carve up the West Roman Empire into several kingdoms. The East Roman Empire survived as the Byzantine Empire until 1453, when the Turks captured Constantinople.

The Roman heritage. The Roman Empire fell from political power. But its culture and institutions survived and shaped Western civilization and the Byzantine world. Roman law became the base of many legal systems in western Europe and Latin America. Latin remained the language of learned Europeans for over 1,000 years. French, Italian, Spanish, and other Romance languages developed from Latin. Roman architecture still inspires the design of public buildings today.

The Roman Empire transmitted its social and economic system to the Middle Ages, the period of European history from the 400's to the 1500's. During the Middle Ages, the Roman Catholic Church replaced the Roman Empire as the unifying force in Europe. The church modelled its administrative structure on the organization of the Roman Empire. It used the Latin language and preserved the classics of Latin literature.

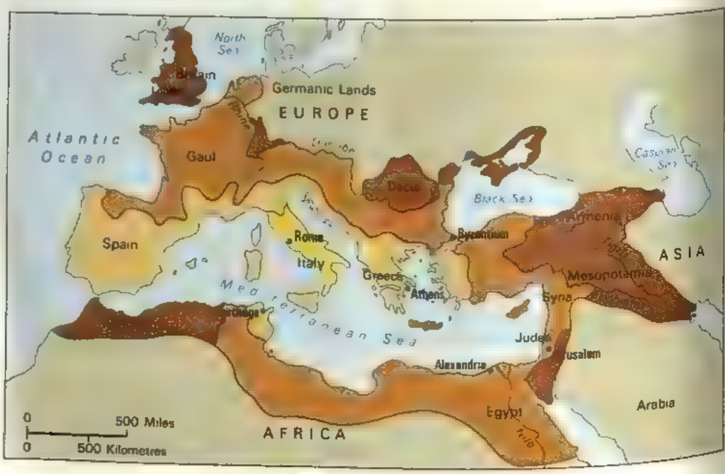
Learning about ancient Rome

Most of our knowledge about ancient Rome comes from written records of the Romans. These records include such documents as law codes, treaties, and de-

Growth of the Roman Empire

Ancient Rome began to expand during the 300's B.C. and by 275 B.C. ruled much of Italy. Expansion overseas made Rome the dominant Mediterranean power by 133 B.C. The Roman Empire grew relatively little after the death of Augustus in A.D. 14. It reached its greatest size under Trajan, who ruled until A.D. 117.

Growth to 275 B.C.
Growth to 133 B.C.
Growth to A.D. 14
Growth to A.D. 117

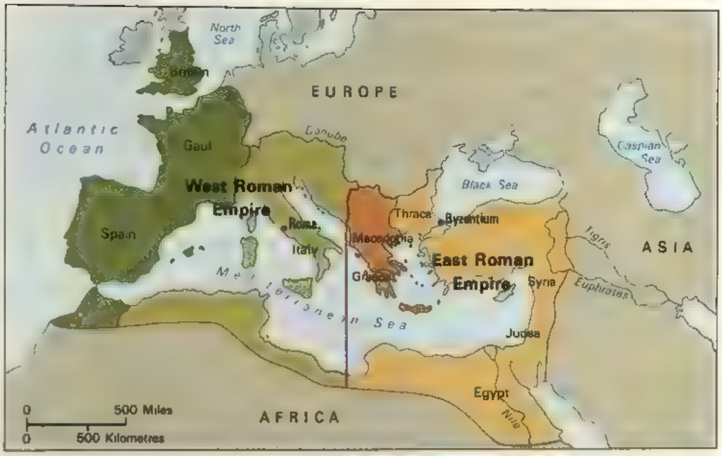


Division of the Roman Empire

The Roman Empire grew weaker during the A.D. 300's. In 395, it was split into the West Roman Empire and the East Roman Empire. Each empire was subdivided into two parts called *prefectures.* The West Roman Empire soon fell to Germanic tribes. But the East Roman Empire survived as the Byzantine Empire until 1453.

West Roman Empire
- Prefecture of Gaul
- Prefecture of Italy and Africa

East Roman Empire
- Prefecture of Illyricum
- Prefecture of the East



crees of the emperors and the Roman Senate. Other written records are masterpieces of Latin literature. In many works, the authors wrote about events they lived through. Such works include the letters and speeches of Cicero and the letters of Pliny the Younger. Julius Caesar wrote about his conquest of Gaul in *Commentaries on the Gallic War.* Roman historians supplied the narrations that connected many of the events that other writers described. Livy told of Rome's development from its legendary origins to his own time, the Augustan Age. Tacitus described the period of Roman history from Emperors Tiberius to Domitian. Suetonius wrote biographies of the rulers from Julius Caesar to Domitian.

Scenes carved on monuments also portray events in Roman history. For example, Trajan's Column and the Column of Marcus Aurelius, both in Rome, tell about Trajan's and Marcus Aurelius' military campaigns.

The remains of Roman towns and cities also provide valuable information. Pompeii and Herculaneum, which lay south of Rome, were buried when Mount Vesuvius erupted in A.D. 79. Excavations of the sites have told us much about everyday life in Roman times.

Interest in the study of ancient Rome reawakened during the Renaissance, the great cultural movement that swept across Europe from the early 1300's to about 1600. The Renaissance started in Italy as scholars rediscovered the works of ancient Greek and Roman authors. In modern times, the first major history of Rome was *The History of the Decline and Fall of the Roman Empire* (1776-1788), a six-volume work by the British historian Edward Gibbon. The German historian Theodor Mommsen produced some important studies on Roman law and history. His *History of Rome* (1854-1856) has influenced all later scholarship on ancient Rome.

Emperors of Rome

Name	Reign†	Name	Reign†
*Augustus	27 B.C.-A.D. 14	*Aurelian	270-275
*Tiberius	14-37	Tacitus	275-276
*Caligula	37-41	Florian	276
*Claudius	41-54	Probus	276-282
*Nero	54-68	Carus	282-283
Galba	68-69	Carinus	283-285
Otho	69	Numerianus	283-284
Vitellius	69	*Diocletian (E)	284-305
*Vespasian	69-79	Maximian (W)	286-305
*Titus	79-81	Constantius I (W)	305-306
Domitian	81-96	Galerius	305-311
Nerva	96-98	Severus	306-307
*Trajan	98-117	*Constantine I	306-337
*Hadrian	117-138	Licinius	308-324
*Antoninus Pius	138-161	Maximinus	310-313
*Marcus Aurelius	161-180	Constantius II	337-361
Lucius Verus	161-169	Constantine II	337-340
Commodus	180-192	Constans	337-350
Pertinax	193	*Julian	361-363
Didius Julianus	193	Jovian	363-364
Septimius Severus	193-211	*Valentinian I (W)	364-375
Caracalla	211-217	*Valens (E)	364-378
Macrinus	217-218	Gratian (W)	367-383
Elagabalus	218-222	Valentinian II (W)	375-392
Severus Alexander	222-235	Eugenius	392-394
Maximinus Thrax	235-238	*Theodosius I	379-395
Gordian I and Gordian II	238	**Emperors of the west**	
Pupienus	238	Honorius	395-423
Balbinus	238	*Valentinian III	425-455
Gordian III	238-244	Petronius Maximus	455-457
Philippus	244-249	Majorian	457-461
Decius	249-251	Libius Severus	461-467
Gallus	251-253	Anthemius	467-472
Aemilianus	253	Olybrius	472-473
Valerian	253-260	Glycerius	473-474
*Gallienus	253-268	Julius Nepos	474-475
Claudius II	268-270	Romulus Augustulus	475-476

*Has a separate article in *World Book.*
†Rome was ruled by two emperors from 161 to 169 and by two or more emperors much of the time from 283 to 395. Sometimes, the empire's eastern (E) and western (W) parts were ruled by separate emperors. At other times, as many as four emperors ruled.

Related articles in *World Book* include:

Biographies

See the table *Emperors of Rome* with this article. For biographies of Roman authors, see the *Related articles* at the end of **Latin literature.** See also:

Agrippina the Younger
Antony, Mark
Brutus, Marcus Junius
Caesar, Julius
Cassius Longinus, Gaius
Catiline
Cato (family)
Cincinnatus, Lucius Q.
Coriolanus, Gaius Marcius
Crassus, Marcus Licinius
Gaius
Galen
Gracchus family
Marius, Gaius
Octavia
Pilate, Pontius
Plotinus
Pompey the Great
Porphyry
Regulus, Marcus Atilus
Roscius, Quintus
Scipio, Publius Cornelius
Spartacus
Sulla, Lucius Cornelius

Buildings and works

Appian Way
Aqueduct
Archaeology (pictures)
Atrium
Basilica
Catacombs
Colosseum
Column
Forum, Roman
Pantheon
Road
Roman Roads
Roman walls

Cities and regions

Galatia
Gaul
Herculaneum
Latium
Numidia
Pompeii
Rome (Ancient city; pictures)

Contributions to civilization

Architecture
Drama (Roman drama)
Geology (The Romans)
Julian calendar
Justinian Code
Latin language
Latin literature
Law (Ancient Roman law)
Library (History)
Mythology
Oratory (Classical orators)
Painting
Roman numerals
Romance languages
Sculpture
Twelve Tables, Laws of the

Daily life

Augur
Bath (History)
Clothing (Clothing through the ages)
Education (History)
Food (Ancient times)
Furniture (Ancient Rome)
Gladiator
Lares and Penates
Lupercalia
Saturnalia
Sibyl
Toga
Triumph

Government

Consul
Dictatorship
Equestrian order
Fasces
Legion
Patricians
Plebeians
Praetor
Praetorian guard
Tribune
Triumvirate

History

See the *History* section of articles on countries that Rome ruled, such as **England** (History). See also:

Actium, Battle of
Barbarian
Byzantine Empire
Etruscans
Flag (pictures: Historical flags of the world)
Punic Wars
Romulus and Remus
Rubicon
Sabines
Ship (Roman ships; pictures)
World, History of the (The Romans)

Outline

I. **The Roman world**
  A. Land
  B. People
II. **Life of the people**
  A. City life
  B. Rural life
  C. Family life
  D. Education
  E. Religion
  F. Food, clothing, and shelter
  G. Recreation
III. **Work of the people**
  A. Agriculture
  B. Manufacturing
  C. Mining
  D. Trade
  E. Transportation and communication
IV. **Arts and sciences**
  A. Architecture and engineering
  B. Sculpture and painting
  C. Literature
  D. Science
V. **Government**
  A. The Roman Republic
  B. The Roman Empire
  C. The law
  D. The army
VI. **History**
VII. **Learning about ancient Rome**

Questions

Why did rhetoric play an important role in higher education in ancient Rome?
Where do we get most of our knowledge of ancient Rome?
What steps did Diocletian take to restore order?
What was an *atrium* and what purpose did it serve?
Why was the army of the Roman Republic made up only of property owners?
Why was building a network of roads so important?
What two reasons help explain Rome's remarkable expansion overseas?
Where do Roman legal principles survive today?
What two engineering achievements made it possible for the Romans to construct large buildings?
How did Roman emperors limit the role of the members of the Roman Senate?

Rome, Treaty of. See **European Union**.

Rome, University of, is the largest university in Italy. It has divisions of architecture; economics and commerce; education; engineering; law; letters and philosophy; mathematics, physics, and chemistry; medicine; pharmacy; political science; and statistical sciences. The university has about 180,000 students. Its library owns about 1 million books and pamphlets.

The university was founded in 1303 by Pope Boniface VIII. During the 1500's, it became famous as a centre for the study of medicine and other sciences. The Italian government has controlled the university since 1870.

See also **Rome** (picture: The University of Rome).

Romeo and Juliet. See **Shakespeare, William** (Shakespeare's plays).

Romero, Oscar Arnulfo (1917-1980), served as archbishop of El Salvador from 1977 until his death. As archbishop, he was the highest official of the Roman Catholic Church in the country. Romero at first avoided becoming involved in political affairs. But in time he came to believe the church should take an active role in bringing social justice to the people. Romero became an outspoken critic of the violence and human rights abuses that El Salvador's military government committed against its citizens and opponents. In 1980, he was assassinated by an unknown gunman while celebrating Mass. Romero's death became a symbol for those who sought peace and change in the country.

Oscar Arnulfo Romero y Galdamez was born in Ciudad Barrios, near the city of San Miguel, El Salvador. He was ordained as a priest in 1942. From 1968 to 1972, Romero served as executive secretary to the Central American Bishop's Secretariat. In 1974, he became bishop in Santiago de María.

Rommel, Erwin (1891-1944), a German field marshal, became one of the most brilliant generals of World War II (1939-1945). He commanded the Afrika Korps, and his clever tactics earned him the nickname of The Desert Fox. But in 1942, he was stopped by British forces in Egypt. In 1944, he led some of the troops that opposed the Allied invasion of Normandy. He lost his command because he reported to Adolf Hitler that it was futile for Germany to continue the war. He was implicated in the plot to kill Hitler in July 1944. Rommel was given his choice of trial or poison. He chose death by poison. Rommel was born in Heidenheim.

Romney, George (1734-1802), a British painter, became noted for his portraits. In his time, he ranked with Sir Joshua Reynolds in popularity, but the work of both Reynolds and Thomas Gainsborough is now considered

National Portrait Gallery, London

George Romney was one of Britain's finest portrait painters. A self-portrait, *above,* shows his masterly skill.

superior. Romney showed his greatest talent in his portraits of women. His best-known model was Emma Hart, who later became Lady Hamilton. Romney painted about 50 portraits of her, sometimes depicting her as a character from history, mythology, or the Bible. Romney was born at Dalton in Furness, in Cumbria, England.

Romulo, Carlos Pena (1899-1985), a Filipino diplomat and author, served as Philippine secretary (later minister) of foreign affairs from 1965 to 1984. Romulo served as Philippine ambassador to the United States in 1952 and 1953, and from 1955 to 1962. He was his country's representative at the United Nations (UN) from 1946 to 1954. In 1949, he became the first Asian president of the UN General Assembly. Romulo represented the Philippines on the UN Security Council in 1957. He served as president of the University of the Philippines from 1962 to 1969 and was also secretary of education from 1966 to 1969.

Romulo was born in Manila and educated at the University of the Philippines and Columbia University, in the United States. For 20 years, he edited a chain of Philippine newspapers. He won a Pulitzer Prize in 1942 for a series of articles he wrote on political and military affairs in Southeast Asia.

Romulus and Remus, in Roman mythology, were twin brothers who founded the city of Rome. The Romans considered Romulus their first king.

According to tradition, Romulus and Remus were born in the ancient Italian city of Alba Longa. King Numitor ruled Alba Longa until Amulius, his younger brother, deposed him. Amulius killed Numitor's sons and forced Rhea Silvia, Numitor's daughter, to become a Vestal Virgin. Vestal Virgins were priestesses who by law had to remain virgins. Amulius hoped that Rhea Silvia's being a Vestal Virgin would prevent her from bearing children who might threaten his rule. But the god Mars seduced Rhea Silvia, and she gave birth to Romulus and Remus. Amulius had Rhea Silvia executed and ordered the babies placed in a basket and thrown into the Tiber River.

After floating downstream, the twins were washed ashore. A female wolf found the infants and nursed them. A shepherd named Faustulus discovered Romulus and Remus. Faustulus and his wife raised the boys as their own children. When the twins became young men, they learned their true identity. They killed Amulius and restored Numitor to the throne in Alba Longa.

Soon, Romulus and Remus set out to found their own city. However, the brothers quarrelled over the site where the city should be built. To settle the argument, they agreed that the one who saw the largest number of vultures in flight should choose the site. Romulus claimed he saw 12 vultures. Remus, who saw only 6 vultures, thought his brother had cheated. After Romulus began to build a wall around his chosen site, Remus leaped over the ditch that was to hold the foundation of the wall. As he did so, he mocked Romulus. For this act of disloyalty, Remus was killed, either by Romulus himself or by one of Romulus's followers. Romulus then became the sole ruler of the city, which he named Rome after himself.

Rome prospered, but only men lived there. To provide wives for his subjects, Romulus had women kidnapped from the neighbouring Sabine tribe (see **Sabines**). Romulus was a wise and popular ruler and a fine military leader. He expanded Rome until it became the most powerful city in its region.

After reigning for 38 years, Romulus disappeared mysteriously during a storm. According to a later myth, he became the god Quirinus.

See also **Mythology** (Roman mythology); **Quirinus; Rome, Ancient** (picture: The legendary founders of Rome.)

Roncalli, Angelo Giuseppe. See **John XXIII** (pope).

Rondo is a form of musical composition in which the principal section or theme is repeated at least three times in the same key. Contrasting sections appear between the principal themes. The name *rondo* refers to the cyclic nature of the form. If *A* represents the principal section or theme, and *B* and *C* the contrasting sections, the sequence of sections might be ABACA, or ABACABA, and so on.

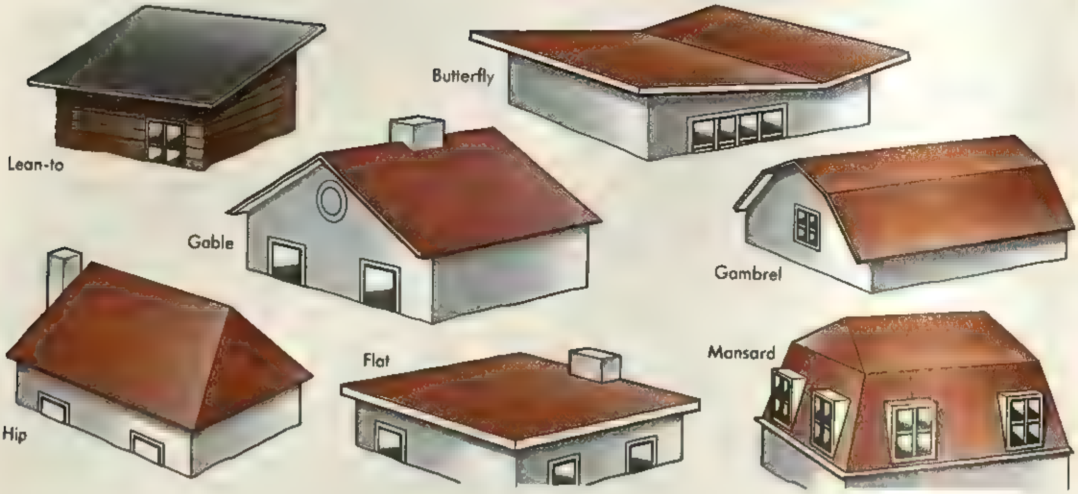
Ronsard, Pierre de (1524-1585), often called the Prince of Poets, led an influential group of French poets called the *Pléiade.* The *Sonnets for Hélène* (1578), perhaps his best-known work, explored the joys and sorrows of love in masterful and descriptive verse. Ronsard's *Odes* (1550-1556) were inspired by Greek and Latin poetry. He wrote many volumes of love poetry and the moral and philosophical *Hymnes* (1555-1556). In *Discours* (1560-1563), he wrote stirring attacks against the Protestant movement during the religious wars that shook France in the 1560's.

Ronsard was born in the family manor house near Vendôme, and trained to be a diplomat. He turned to literature after he became partially deaf.

See also **French literature** (The Pléiade).

Roof is the cover of any building. The term also includes the materials that support the roof. Climate often determines the design of roofs. Ancient Syrians and Egyptians used flat roofs because of the hot sun and the

Types of roofs



lack of rain. Steep, sloping roofs covered the homes of central Europe, to help drain off heavy rains.

There are many variations of flat and sloping roofs. A *gable* roof has two sides sloping up to a centre ridge. The *hip* roof has four sides sloping up from all four walls. The *lean-to* is a single slope over a small building, usually set against a larger building. A *gambrel* roof has two added ridges parallel to the centre gable ridge, making steep slopes below each side of the upper, flatter slopes. *Mansard* roofs also have ridges below the centre one, but on four sides, like the hip roof. Water is drained beyond the walls of a building by the *eaves* (overhang) of the roof.

See also **Architecture** (pictures); **Dome; House; Shelter.**

Rook is the most common European member of the crow family. It is smaller than the raven, and larger than the jackdaw. It differs from other members of its family in having a purple gloss on its black plumage, and in its habit of feeding entirely on insects and grain. Upon reaching maturity, it sheds the feathers of its face, which then becomes a greyish-white. The migrating habits of rooks vary. Those in central Europe remain in their homes all year round. Those farther north fly southward when winter comes. During the nesting season, they gather in communities of many hundreds, known as rookeries. Tame rooks sometimes learn to imitate human speech. They are known for their cunning. See also **Crow.**

Scientific classification. The rook belongs to the crow family, Corvidae. It is *Corvus frugilegus.*

Rooke, Sir George (1650-1709), a British admiral, was commander in chief of the fleet that captured Gibraltar in 1704. A few days later, he encountered a larger French fleet off the coast of Gibraltar. The battle itself was inconclusive. But, after the battle, the French made no further attempt to recapture Gibraltar.

Rooke was probably born at Canterbury. His naval career started in 1672. At La Hogue in 1692, he led a force that set fire to part of the French fleet. Rooke became an MP in 1698. After the battle of Gibraltar, the Whig government removed him from command, supposedly because he had failed to win the battle. But the real reason for his dismissal was that he had Tory support.

Room-and-pillar mine. See **Coal** (The room-and-pillar system).

Roosevelt, Eleanor (1884-1962), the wife of President Franklin D. Roosevelt, became a distinguished public figure in her own right. She was probably the most active first lady in American history. Mrs. Roosevelt, a niece of President Theodore Roosevelt, won fame for her humanitarian work.

Mrs. Roosevelt was christened Anna Eleanor Roosevelt. But her family called her Eleanor, and she rarely used her real first name. In 1905, she was married to Franklin D. Roosevelt, a distant cousin. She began to work politically in his behalf after a polio attack crippled him in 1921. While Roosevelt was governor of New York and later President, she frequently made fact-finding trips for him. During World War II (1939-1945), Mrs. Roosevelt travelled to Europe, Latin America, and other parts of the world. She began to work with young people and the underprivileged, and fought for equal rights for minority groups.

From 1945 to 1951, Mrs. Roosevelt served as a delegate to the United Nations General Assembly. In 1946, she was elected chairman of the UN's Human Rights Commission, part of the Economic and Social Council. She helped draft the Universal Declaration of Human Rights (see **Human Rights, Universal Declaration of**). In 1961, she returned to the General Assembly.

Mrs. Roosevelt wrote several books. They include *This Is My Story* (1937), *On My Own* (1958), and *Tomorrow Is Now* (published in 1963, after her death).

See also **Roosevelt, Franklin Delano.**


Eleanor Roosevelt

Roosevelt, Franklin Delano (1882-1945), was the only president of the United States who was elected four times. He served as president for more than 12 years, from 1933 to 1945, longer than any other person. He died 83 days after becoming president for the fourth time.

Roosevelt became president at the height of the Great Depression. About 25 per cent of the workers in the United States had lost their jobs. Many families lacked money for necessities. Others had lost their homes because they could not keep up mortgage repayments. Millions of Americans feared what would happen next. In Roosevelt's first inaugural address, he called for faith in America's future. "The only thing we have to fear is fear itself," he declared boldly.

A new era in American history began under Roosevelt. He called his programme the *New Deal*. Roosevelt promised relief for unemployed workers and said he would help farmers. Under his leadership, the government put stronger controls on business companies than ever before. It spent billions of dollars on relief and public works to "prime the pump" of business activity. Dozens of new government agencies were set up. Roosevelt's name was to appear often in headlines, and he became widely known by his initials, F.D.R.

The start of World War II in 1939 divided Roosevelt's presidency into two parts. Until the German invasion of Poland that year, the government worked hard to end the depression. The war then became the chief concern of Roosevelt and the United States.

Franklin Delano Roosevelt was president of the United States of America for more than 12 years.

Early life

Boyhood and education. Roosevelt was born on Jan. 30, 1882, on his father's estate, Springwood, in Hyde Park, New York, U.S.A. He was the only child of James and Sara Roosevelt. James Roosevelt was a wealthy vice president of the Delaware and Hudson Railway. His wife was a member of the wealthy Delano family.

Franklin was educated at Groton School, in Groton, Massachusetts, U.S.A. In 1900, he enrolled at Harvard University where he studied history. He graduated from Harvard in 1903. In 1904, Roosevelt entered Columbia University Law School. He passed the bar examination in 1907. He worked as a clerk for a law firm in New York City for the next three years. But he showed no enthusiasm for legal work.

Entry into politics. In 1910, Roosevelt won election to the New York senate, where he soon became known as a bold and skilful political fighter.

The United States entered World War I in April 1917. Roosevelt, who was then assistant secretary of the navy, worked on many wartime projects, including a plan to lay antisubmarine mines in the North Sea. In 1918, he toured European battlefields and met with military leaders overseas. Roosevelt had become a national figure.

In 1920, the Democratic National Convention nominated Governor James M. Cox of Ohio as presidential candidate, and Roosevelt as vice-presidential candidate; but the Republican candidates defeated them easily.

Disabled by polio. The Roosevelt family had a summer home on Campobello Island, off New Brunswick, Canada. On Aug. 9, 1921, Roosevelt fell into the water while sailing. He caught a chill, and the next day, he felt tired. By August 12, Roosevelt could not stand or even move his legs. He suffered severe pain. His back, arms, and hands became partially paralysed. He could no longer hold a pen to write. He was the victim of a severe case of polio myelitis.

In January 1922, Roosevelt's condition suddenly became worse. Many people thought his political career had ended. His mother urged him to retire. But he continued his political activity. He received encouragement and help from his wife, Eleanor, and from his aide, Louis Howe. He began to fight back against the disease that had crippled him. He regained the use of his hands, and the paralysis left his back. His legs improved a little. He could stand at a speaker's podium, but he had to use leg braces and never walked without some form of help.

In 1924, Roosevelt began to spend several months of each year at Warm Springs, Georgia, U.S.A. Many polio victims had been helped by swimming in the pool of warm mineral water there. At the springs, Roosevelt met patients who could barely afford the cost of polio treatment. In 1926, he bought the springs and the surrounding land. The next year, with a group of friends, he established the Georgia Warm Springs Foundation. For many years, the foundation provided low-cost treatment for polio victims.

Return to politics. Roosevelt made a spectacular return to national politics in 1924. He nominated Governor Alfred E. Smith of New York for president at the Democratic National Convention. The nominating speech was Roosevelt's first major public appearance since his polio attack. Thundering cheers greeted him as he moved slowly to the podium, supported by his son James. Smith did not get the nomination. But Roosevelt gained attention as a Democratic leader and as a brave man

Swimming was one of Roosevelt's favourite sports after he contracted polio in 1921. He is shown here at Warm Springs, Georgia, where he set up a foundation to treat polio victims.

who had not let a debilitating disease drive him from public life.

In 1928, Roosevelt was elected governor of New York. As governor, he supported a variety of progressive legislation. He obtained tax relief for farmers. After the Great Depression began in October 1929, he established the first system of relief for the unemployed in New York. In 1930, Roosevelt won reelection by about 725,000 votes, a record for the state at that time.

Election of 1932. By 1932, Roosevelt, who had gained wide public respect for his work as governor, was seeking the Democratic presidential nomination. In a nationwide radio address, he outlined a programme to meet the economic problems of the nation. Such a programme, he said, had to be built for the average American, whom he called the "forgotten man." The Democratic National Convention nominated Roosevelt on the fourth ballot. John Nance Garner of Texas, the Speaker of the House of Representatives, was chosen for vice president. The Republicans renominated President Herbert Hoover and Vice President Charles Curtis.

In the election, Roosevelt received 472 electoral votes to 159 for Hoover. The Democratic campaign song was "Happy Days Are Here Again."

First administration (1933-1937)

Roosevelt became president on March 4, 1933, at the age of 51.

The depression had grown steadily worse. Thousands of unemployed workers were standing in bread lines to get free food for their families. Many farmers and city workers had lost their homes. Even more were about to lose their homes because they could not keep up their mortgage repayments.

The banking crisis. About three weeks before Roosevelt took office, a banking panic began. It spread throughout the country as anxious depositors hurried to their banks to get cash and gold. The panic created "runs" that ruined many banks.

Roosevelt declared a "bank holiday" that began on March 6, 1933. He closed all banks in the United States until the Department of the Treasury could examine every bank's books. Banks in good financial condition were to be supplied with money by the Treasury and allowed to reopen. Those in doubtful condition were kept closed until they could be put on a sound basis. Many banks never reopened. The president's action restored confidence and ended the bank crisis. People knew that if a bank opened its doors, it was safe. Few people wished to withdraw their money from a bank they knew was sound.

The "Hundred Days." On March 9, 1933, Congress began a special session called by Roosevelt. The president at once began to submit recovery and reform laws for congressional approval. Congress passed nearly all the important bills that he requested, most of them by large majorities. This special session of Congress came to be known as the "Hundred Days." Important laws passed included the Agricultural Adjustment Act (AAA), the Tennessee Valley Authority Act (TVA), and the National Industrial Recovery Act (NIRA).

On March 12, Roosevelt gave the first of his famous "fireside chats," speaking to the nation by radio. He explained what action had been taken and what he planned for the immediate future.

Many of the advisers who helped Roosevelt during his presidential campaign continued to aid him after he entered the White House. A newspaperman once described the group as "Roosevelt's Brain Trust." The name stuck.

The New Deal, as Roosevelt called his reform programme, included a wide range of activities. The president described it as a "use of authority of government as an organized form of self-help for all classes and groups and sections of our country."

Unemployment legislation. At first, Roosevelt favoured only emergency measures. At his request, Congress appropriated 500 million U.S. dollars for relief to states and cities through the Federal Emergency Relief Administration. In the winter of 1933 to 1934, the government started a relief programme called the Civil Works Administration (CWA). The CWA supplied funds to local authorities such as mayors of cities and governors of states. Those funds made possible such public projects as cleaning up parks and building streets, roads, bridges, and schools. Some people criticized the CWA. They said many of its employees merely raked leaves or held useless jobs.

Roosevelt ended the CWA after a few months. But other employment relief programmes, such as the Civilian Conservation Corps (CCC) and the Works Projects Administration (WPA), were longer lasting. In 1935 the Social Security Act authorized unemployment relief and old-age pensions.

Opposition to the New Deal. By 1935, some New Deal measures were meeting strong opposition, chiefly from the nation's business leaders. They charged that such measures as the WPA wasted money.

Good Neighbor Policy. Roosevelt described his foreign policy as that of a "good neighbor." This phrase came to be used to describe the U.S. attitude toward the countries of Latin America. Under Roosevelt's Good Neighbor Policy, the United States took a stronger lead in promoting goodwill among these nations.

Relations with the Soviet Union. Roosevelt hoped that trade could be resumed between the United States

"Fireside chats" became a regular feature of Roosevelt's presidency. These informal radio reports to the American people enabled Roosevelt to gain widespread support for his programmes.

and the Soviet Union. His administration recognized the Soviet government in November 1933. Relations between the United States and the Soviet Union had been broken off after the Russian Revolution of 1917. In 1933, for the first time in 16 years, the countries exchanged diplomatic representatives.

Election of 1936. The Democratic National Convention renominated Roosevelt by acclamation in 1936. The delegates also renominated Vice President Garner. The Republicans picked Governor Alfred M. Landon of Kansas for presidential candidate.

Roosevelt won reelection in a landslide. He received 523 electoral votes to 8 for Landon, and won every state except Maine and Vermont.

Second administration (1937-1941)

Attitude toward Japan. In the mid-1930's, Roosevelt realized that Japanese attacks on China were a threat to world peace. In October 1937, he called on peaceful countries to write and "quarantine" war in the same way that doctors quarantine a contagious disease. But he did not follow up on this speech, and no such action occurred.

Roosevelt and secretary of state Cordell Hull believed that the U.S.A. needed a policy that would help the country arm for defence. The president tried to strengthen the army and the navy, though Congress often opposed him. He refused to recognize the Japanese puppet state of Manchukuo in northern China. He believed Japan should respect American rights in the Pacific and East Asia. The president demanded that Japan apologize and pay for the sinking of the American gunboat *Panay* in 1937. The Japanese met his demands at once.

Neutrality acts of the 1930's reflected the desire of many Americans to isolate the United States from other nations. Congress passed the first Neutrality Act in 1935. It prohibited the United States from furnishing weapons or supplies to any nation at war. Roosevelt said he hoped that any future neutrality laws "might provide greater flexibility." But in 1936 and 1937, Congress and Roosevelt approved other legislation to keep America free of "foreign entanglements."

World War II began on Sept. 1, 1939, when Germany invaded Poland. Still, many Americans did not agree that the situation was as dangerous as Roosevelt believed. Roosevelt thought that a victory by the Axis powers—Germany, Italy, and Japan—would endanger democracy everywhere in the world. The isolationists in the United States thought the U.S.A. could stay out of the war. Some isolationists accused Roosevelt of *warmongering*, trying to get the U.S.A. into the war.

Shortly after the German troops attacked Poland, Congress passed the Neutrality Act of 1939. The law made it possible for a nation fighting the Axis to buy war supplies from the United States. But the nation had to pay for the weapons in cash and furnish its own ships to carry them. In November 1941, Congress repealed two sections of the act that had kept American vessels out of war zones and had forbidden them to carry guns.

Election of 1940. The Democratic Party broke precedent in 1940 by nominating Roosevelt for a third consecutive term. Secretary of agriculture Henry A. Wallace was chosen as his vice-presidential candidate. The Republicans nominated Wendell L. Willkie of Indiana, a corporation president, to oppose Roosevelt. They picked Senator Charles L. McNary of Oregon for their vice-presidential candidate.

The Republicans based their campaign on the tradition that no president had ever sought three terms in succession. Roosevelt defended his administration's programmes. He promised to try to keep the nation out of war. In June, France surrendered to Germany. The defeat of the French Army, believed by many to be the strongest in the world, shocked the United States. Most Americans decided that Roosevelt's leadership and experience were needed for another term. Roosevelt carried 38 of the 48 states and won 449 electoral votes to 82 for Willkie.

Third administration (1941-1945)

Eve of war. By the time Roosevelt took his third presidential oath of office, the United States was preparing to give the United Kingdom all aid short of war. In the summer of 1940, the UK gave the United States 99-year leases on several naval bases in the Atlantic Ocean. The British Navy received 50 old American destroyers in return. The United States adopted its first peacetime selective service, or conscription, law in September.

In August 1941, Roosevelt met the British Prime Minister Winston Churchill on a cruiser anchored off Newfoundland, Canada. The two men adopted a declaration that became known as the *Atlantic Charter*. They pledged not to seek gains, "territorial or otherwise"; to respect the right of every nation to choose its own form of government; to guarantee freedom of the seas; and to conduct peaceful world trade.

In a speech on Jan. 6, 1941, Roosevelt declared that all people are entitled to freedom of speech, freedom of worship, freedom from want, and freedom from fear. These basic rights came to be called the *Four Freedoms*. On March 11, Congress passed the Lend-Lease Act. That law authorized the government to provide war supplies

to any nation that the president deemed vital to U.S. security.

Relations with Japan became increasingly tense. Germany, Italy, and Japan had signed a defence pact in 1940. The U.S.A. opposed Japanese aggression in Southeast Asia. It reduced trade with Japan and issued warnings from time to time.

America goes to war. On Sunday, Dec. 7, 1941, Secretary of State Hull conferred with two Japanese diplomats. While they talked, Japanese planes attacked the U.S. Pacific Fleet, which lay at anchor in Pearl Harbor, Hawaii.

Roosevelt addressed Congress the next day. He said December 7 was "a date that will live in infamy." The United States declared war against Japan. Three days later, on December 11, Germany and Italy declared war on the U.S.A. America then declared war on those countries.

Most Americans realized the nation faced a serious situation. The war extended across the Atlantic and Pacific oceans. The navy had been crippled by the attack on Pearl Harbor. But conscription had given the army more than a million men with at least a year's training.

A great decision confronted the president after Pearl Harbor. He had to decide where to strike first—against Germany or against Japan. Roosevelt conferred with Churchill in the White House in December 1941 and January 1942. The two leaders realized that the United States could not strike an effective blow against Japan until the U.S. Navy had recovered from its losses at Pearl Harbor. In addition, German scientists were developing new weapons that could mean defeat for the UK, U.S.A., and other *Allies* (countries fighting against Germany, Italy, and Japan). British and Soviet citizens wanted to see Germany defeated as soon as possible. For these reasons, Roosevelt and Churchill decided that Germany, the most powerful enemy nation, must be defeated first.

Roosevelt suggested the name *United Nations* for the alliance that fought Germany, Italy, and Japan. This alliance formed the basis for the peacetime United Nations organization that was established later in 1945.

The Big Three. Roosevelt left the United States many times during the war for conferences with Allied leaders. He was the first president to leave the country in wartime. Early in 1943, he met with Churchill in Casablanca, Morocco. The two leaders announced that they would accept only unconditional surrender by the Axis nations. In other conferences, Roosevelt discussed problems of war and peace with both Churchill and Soviet Premier Joseph Stalin. They came to be known as the "Big Three." Roosevelt also conferred with Generalissimo Chiang Kai-shek of China in 1943.

Early in the war, the Soviet Union asked for a "second front" against the Germans in Western Europe. Churchill believed the Allies should first attack the Germans in Africa or in other places where they were relatively weak. He also feared that the Soviet Union would take control of Eastern Europe after the war. In November 1943, the Big Three met at Teheran, Iran. During and after that conference, Roosevelt worked to get Churchill and Stalin to agree on major war aims.

Election of 1944. In June 1944, the Republicans nominated Governor Thomas E. Dewey of New York as a presidential candidate and Governor John W. Bricker of Ohio as vice-presidential candidate. Roosevelt easily won renomination by his party. Senator Harry S. Truman of Missouri was nominated for vice president. In the election Roosevelt won 36 of the 48 states and received 432 electoral votes to 99 votes for Dewey.

Fourth administration (1945)

Roosevelt was in poor health when he started his fourth term. In the autumn and winter of 1944, Roosevelt had been busy directing his legislative programme and dealing with increasingly difficult international problems. The presidential election campaign had weakened him further.

Yalta Conference. Two days after his fourth inauguration, Roosevelt left to meet Churchill and Stalin at Yalta, a resort in the Crimea in the southern Soviet Union. On Feb. 11, 1945, the three leaders issued the Crimea Declaration. It repeated the principles of the Atlantic Charter and the Casablanca conferences. The leaders mapped the final assault on Germany and the postwar occupation of that country. They also planned a meeting in San Francisco, to lay the foundations for the peacetime United Nations organization. In a secret agreement, the Soviet Union promised to enter the war against Japan within three months after the surrender of Germany. In return, the Soviet Union was to receive the Kuril Islands and other concessions. Critics later charged that Roosevelt had been cheated by Stalin.

During the next few weeks, Roosevelt began to have doubts about the goodwill of the Soviets. He was anxious, he told Churchill, about "the development of the Soviet attitude."

Death. On March 29, 1945, Roosevelt left for a rest at Warm Springs. He had prepared a speech for broadcast on April 13. He had written: "The only limit to our realization of tomorrow will be our doubts of today. Let us move forward with strong and active faith."

April 12 began as usual. The president read newspapers and mail in the morning. He planned to attend a barbecue in the afternoon. Before the barbecue, Roosevelt was working at his desk while an artist, Elizabeth Schoumatoff, painted his portrait. Suddenly he fell over in his chair. "I have a terrific headache," he whispered. These were his last words. Roosevelt died a few hours later of a cerebral haemorrhage.

Related articles in ***World Book*** include:

Churchill, Sir Winston	Teheran Conference
Great Depression	Truman, Harry S.
New Deal	World War II
Stalin, Joseph	Yalta Conference

Important dates in Roosevelt's life

1882	(Jan. 30) Born in Hyde Park, New York, U.S.A.
1905	(March 17) Married Eleanor Roosevelt.
1913	Appointed assistant secretary of the U.S. Navy.
1920	Ran unsuccessfully for vice president of the United States.
1921	Stricken with polio.
1928	Elected governor of New York.
1932	Elected president of the United States.
1936	Reelected president.
1940	Reelected president.
1944	Reelected president.
1945	(April 12) Died in Warm Springs, Georgia, U.S.A.

Roosevelt, Nicholas J. (1767-1854), was an American inventor and engineer. He helped pioneer the development of steamboats.

Roosevelt was born in New York City. He became interested in mechanics as a youth and, at about the age of 15, he designed a paddle wheel to drive a model boat. In 1809, Roosevelt and the U.S inventor Robert Fulton joined in a venture to introduce steamboats on Western rivers. In 1812, Roosevelt completed a voyage from Pittsburgh to New Orleans in their boat, the *New Orleans.* The trip was the first steamboat voyage on the Ohio and Mississippi rivers. The *New Orleans* was a success and continued to travel for about two years. Roosevelt patented the use of vertical paddle wheels in 1814. They became the chief method of propelling steamboats.

Roosevelt, Theodore (1858-1919), was president of the United States from 1901 to 1909. Roosevelt won wide popularity as president, and used his power of leadership to help the U.S.A. meet many challenges at home and abroad.

Early life. Roosevelt was born in New York City on October 27, 1858. As a child, he visited Europe and the Middle East with his wealthy family. A Republican, he won election to the New York state assembly in 1881.

In 1897, President William McKinley appointed Roosevelt assistant secretary of the navy. Roosevelt worked to strengthen the navy. He believed that sea power was the decisive factor in world history, and that war for a righteous cause brought out the finest virtues in people and nations.

From Rough Rider to president. Since 1895, Cubans had been revolting against their Spanish rulers. Many Americans demanded that the U.S.A. help the Cubans. On Feb. 15, 1898, the U.S. battleship *Maine* exploded for no obvious reason in Havana harbour, Cuba. Roosevelt tried to rush preparations for war against Spain. He became impatient with McKinley's attempts to avoid war. Roosevelt started to recruit men for a cavalry regiment, which became known as the "Rough Riders". Most of the men were former college sportsmen or Western cowboys.

On July 1, 1898, Colonel Roosevelt led his men in a charge up Kettle Hill near Santiago, Cuba. Other U.S. troops assaulted Spanish forces on nearby San Juan Hill. Santiago surrendered on July 17. Roosevelt and the Rough Riders became nationally famous.

Roosevelt's war record helped him win election as governor of New York in 1898. As governor, Roosevelt became an efficient, independent administrator. He supported mild civil reform legislation. He noted to a friend at the time, "I have always been fond of the West African proverb: 'Speak softly and carry a big stick, you will go far' ". Roosevelt's policy of "big stick" diplomacy would continue into his presidency.

President McKinley stood for reelection in 1900 and chose Roosevelt as his vice-presidential candidate. On Sept. 6, 1901, only six months after his second inauguration, President McKinley was shot by an assassin. He died on Sept. 14, and Roosevelt became president.

First administration (1901-1905). Roosevelt kept all the members of McKinley's Cabinet. He said he would continue McKinley's policies, but he had too much originality to follow another person's plans.

Oil painting on canvas (1903) by John Singer Sargent

U.S. President Theodore Roosevelt considered the building of the Panama Canal the greatest achievement of his presidency.

Domestic affairs. Roosevelt sought to limit the power of great business corporations. During his presidency, the government took legal action against a number of corporations on charges of trying to reduce competition in major industries such as railways, petroleum, and tobacco. Many people called Roosevelt a "trust buster," but he said he simply wanted the government to regulate, not "bust," the *trusts* (large business monopolies).

Roosevelt wanted the government to act justly toward trade unions as well as toward business. In 1902, Roosevelt acted to end a strike by the United Mine Workers, a trade union. Although he had no legal authority to intervene, he called a conference of both the union and the coal mine owners to propose that the strike be settled by arbitration.

In 1903, at Roosevelt's request, Congress established the Department of Commerce and Labor (now the Department of Commerce).

Foreign policy. Between 1902 and 1905, Roosevelt persuaded Congress that a U.S. fleet would need to shift rapidly between the Atlantic and Pacific oceans. A canal across Central America seemed necessary.

In 1902, the U.S.A. and the new independent Republic of Panama signed a treaty granting the U.S.A. the use and control of a strip of land on which to dig a canal. Roosevelt said he was prouder of the canal than of any other accomplishment of his administration (see **Panama Canal**).

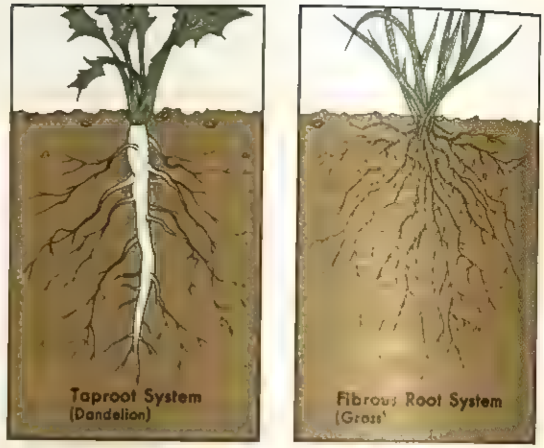
Second administration (1905-1909). Roosevelt demanded legislation to curb growing abuses in the railway industry, and Congress passed laws to regulate it. Under pressure from the president, Congress also passed laws to protect the public from harmful foods and drugs. In 1905, Roosevelt helped end the Russo-Japanese War. During the peace talks that followed,

Roosevelt opposed Japan's demand for compensation payments from Russia. Relations between the U.S.A. and Japan became strained, and Roosevelt feared a Japanese attack on the Philippines, then an American colony. In 1908, Japan and the U.S.A. signed the Root-Takahira Agreement. The two nations promised not to seek territorial gains in the Pacific, and to honour the *Open-Door Policy* in China.

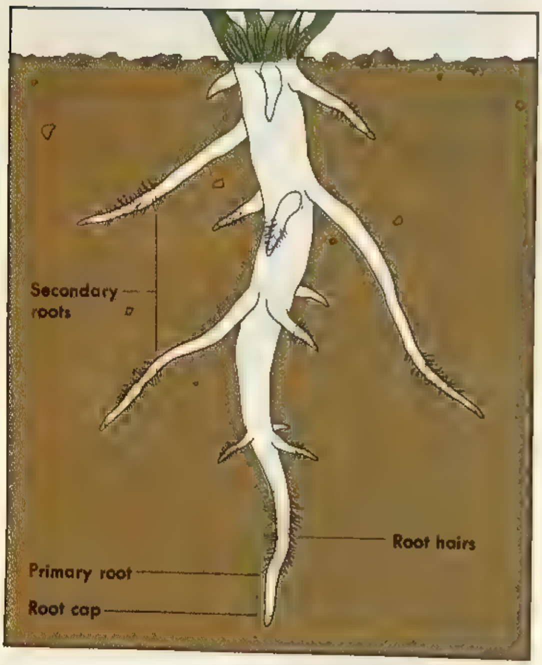
Later years. Roosevelt left the presidency in 1909. World War I began in 1914. Roosevelt urged President Wilson to lead the U.S.A. into war immediately, but the United States did not enter until 1917.

It seemed possible that Roosevelt would once more be nominated as Republican presidential candidate in 1920. But he died of a blood clot in the heart on Jan. 6, 1919, at his home in Oyster Bay, New York, U.S.A.

See also **Spanish-American War; Taft, William Howard.**



The two chief kinds of root systems. In a *taproot system,* the primary root grows straight down and remains larger than secondary roots. In a *fibrous root system,* secondary roots grow in all directions and may be as long as the primary root.



The main parts of a root system are shown above. The *primary root* develops first and produces branches called *secondary roots. Root hairs* grow just above the tip of each root.

Root is one of the three main organs of a plant. The others are the stem and the leaf. Most roots are long and round and grow underground. They anchor the plant in the soil. They also absorb water and minerals that the plant needs to grow. In addition, many roots store food for later use by the plant.

Plants with roots include all seed-producing plants and most spore-producing plants, such as ferns and horsetails. Liverworts, and mosses do not have roots. See **Plant** (Kinds of plants).

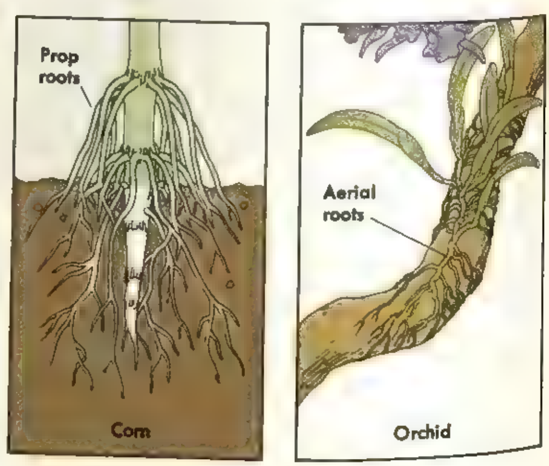
Kinds of roots

The first root to develop from a seed is called the *primary* root. It produces many branches called *secondary* roots which, in turn, produce branches of their own.

A plant may develop one of two main kinds of root systems, *taproot* or *fibrous.* In a taproot system, the primary root grows straight down and is called the *taproot.* The taproot remains larger than any of the secondary roots throughout the life of the plant. In some plants, including beets and carrots, the taproot becomes *fleshy* (swollen).

Grass is an example of a plant with a fibrous root system. In such a system, the primary root does not remain larger than the others. Many slender secondary roots grow out in all directions. A fibrous root system may become very extensive. For example, the roots of a rye plant may have a combined length of about 612 kilometres.

Some plants have modified roots that perform special functions. Roots that grow from the stem above the ground are called *adventitious roots.* They include the *prop roots* of maize and certain other plants. Prop roots grow down into the soil from the lower part of the stem



Specialized roots. *Prop roots* grow from a stem and help brace a plant against the wind. *Aerial roots* cling to tree branches and absorb water and minerals from the tree and the air.

and help brace the plant against the wind. Some species of orchids and other plants that live on tree branches send out *aerial roots,* which cling to the branches. Aerial roots absorb water and minerals from the surface of the tree and from the air. Mistletoe is one of the few plants with roots that penetrate the limbs of a tree. These roots, called *sinkers,* absorb food, water, and minerals directly from the tree.

Parts of a root

The root tip. A root grows in length from an area at its *apex* (tip). This growth area is called the *apical meristem.* A meristem is any part of a plant where the cells divide rapidly, forming new cells continually. The apical meristem is covered by the *root cap,* a thimble-shaped group of cells. The root cap protects the delicate root tip from damage as the root grows in length and the tip pushes through the soil.

The cells produced by the apical meristem are all small and nearly identical. In the *region of elongation,* just behind the apical meristem, the cells rapidly grow longer. Farther back lies the *region of maturation.* There, the cells *differentiate*—that is, they take on a different structure and appearance according to their functions in the mature root. The distance from the root cap to the region of maturation is only a few millimetres.

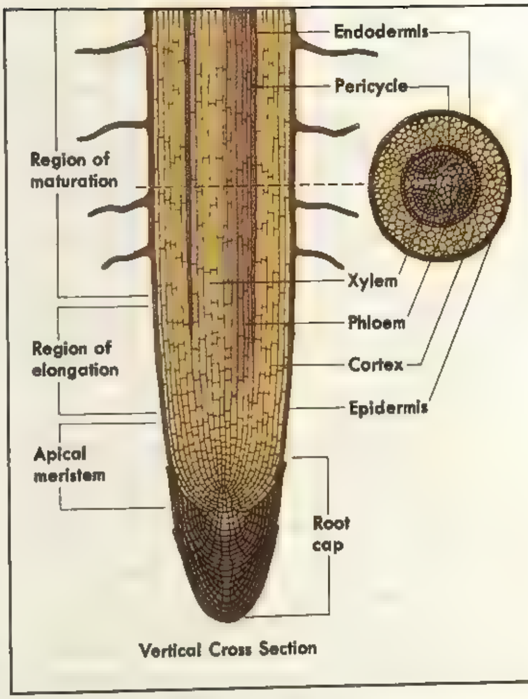
The outer tissues. The outer layer of cells of a root is called the *epidermis.* It serves as a sort of skin and protects the tissues beneath. Tiny, hairlike extensions called *root hairs* grow from the epidermis. The root hairs absorb most of the water and minerals that a plant takes in from the soil. In most kinds of plants, the root hairs live only a few days. They occupy the *root hair zone,* an area just above the root tip. This area is only a few millimetres long.

A thick layer of rounded cells called the *cortex* lies just inside the epidermis. These cells contain stored food and water. The inner layer of cells of the cortex makes up the *endodermis.*

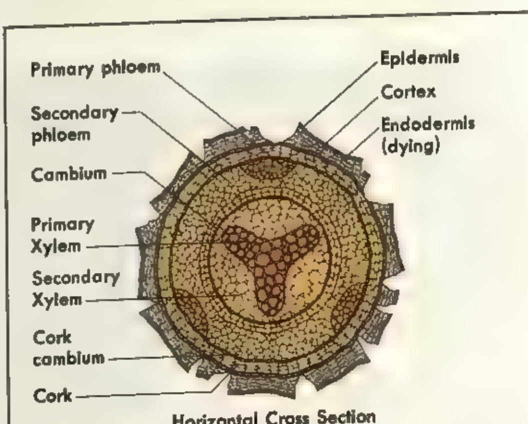
The core, or *stele,* is the central portion of the root. Its outer layer of cells is called the *pericycle.* Branch roots grow from the pericycle. Inside the pericycle are two kinds of tissues, *xylem* and *phloem.* Xylem includes rows of dead, tubular cells called *vessels,* which conduct water and minerals up to the stem and leaves. Phloem consists largely of rows of long, living cells called *sieve tubes.* These cells transport food down from the leaves for use or storage by the root. In most roots, the xylem forms a pattern shaped like a star or the spokes of a wheel. The phloem lies between the points of the star or between the spokes.

Secondary tissues. All the tissues described so far have been *primary tissues.* Such tissues differentiate from cells created in the apical meristem. Many plants that live just one year have only primary tissues in their roots. But other plants, especially those that live more than one year, have *secondary tissues* in their roots in addition to primary tissues. The growth of primary tissue adds to the length of a root. Secondary tissues add to the root's thickness. Secondary-tissue growth produces the large, brown, woody roots in trees, shrubs, and other plants that live for many years.

Secondary tissues develop from two meristems. One, called the *cork cambium,* originates beneath the epidermis, generally in the pericycle. It produces cork cells and pushes them toward the outside of the root. As the cork expands outward, the endodermis, cortex, and epidermis die and peel off. The cork replaces them and becomes the outer covering of the root. The other secondary meristem, the *cambium,* lies between the primary xylem and the primary phloem. It produces secondary xylem cells toward the centre of the root, and secondary phloem cells toward the outside.



The root tip comprises the regions in which cells divide *(apical meristem),* grow longer *(region of elongation),* and become specialized *(region of maturation).* The *root cap* protects the tip.



Secondary tissues develop in some kinds of roots. The *cambium* produces secondary xylem and phloem. The *cork cambium* produces cork. As the cork expands, the outer tissues die.

The importance of roots

Fleshy taproots rank among the most important vegetables. They include beets, carrots, radishes, swedes and turnips. Sweet potatoes are a root used not only as food, but also in making alcohol, starch, and syrup. Roots of the cassava plant are a popular food in the tropics. The roots of tropical yams are used in producing cortisone and related drugs.

Roots help prevent erosion of soil by wind and water. Soil is held in place by the dense network of roots of grasses, trees, and other plants. Plants called *legumes,* which include clover, peas, and soybeans, help enrich the soil. Swellings on their roots contain bacteria that convert nitrogen from the air into compounds useful to the plant. After the plant dies, these compounds become part of the soil.

See also **Alfalfa** (picture); **Carrot; Mangrove; Plant** (Factors affecting plant growth; pictures).

Root, in mathematics, is a quantity that yields a given quantity when it is taken as a factor a specified number of times (see **Factor**). The number of times the root is taken as a factor is called its *index.* Roots are named from their indexes. Thus, 3 is a *fourth* root of 81, because $3 \times 3 \times 3 \times 3 = 81$. Roots with indexes of 2 and 3 are also called *square roots* and *cube roots,* respectively. The positive *n*th root of a positive number p is indicated by $\sqrt[n]{p}$. Thus, $\sqrt[4]{81} = 3$. The symbol $\sqrt{}$ is called a *radical sign.* When no index is shown, the index is 2.

A root in algebra is a solution of an equation—that is, it is a quantity which, when substituted for the variable in an equation, satisfies the equation. For example, 3 is a root of $x+2=5$, because if 3 is substituted for the variable x, the equation correctly reads $3+2=5$. See also **Algebra; Cube root; Square root.**

Root, Elihu (1845-1937), an American statesman, is best remembered for his efforts to assure international peace. From 1905 to 1909, he served as secretary of state under President Theodore Roosevelt. As secretary of state, Root worked to improve United States relations with Latin-American countries and Japan. He also negotiated many treaties in order to end disputes between the United States and other countries. In 1912, he received the Nobel Peace Prize for his contributions to world peace.

Root served as president of the Carnegie Endowment for International Peace from 1910 to 1925. In 1920 and 1921, he helped organize the Permanent Court of International Justice. For the next 10 years, he battled unsuccessfully to get the United States to join the court.

Root was born in Clinton, New York. He graduated from the New York University Law School in 1867. He soon became a highly successful corporate lawyer in New York City. Root served as United States secretary of war from 1899 to 1904, under Presidents William McKinley and Theodore Roosevelt. In 1901, he founded the Army War College. Root also drafted the Platt Amendment to the constitution of Cuba. This amendment, adopted in 1901, gave the United States the right to intervene in Cuban affairs. Root represented New York in the United States Senate from 1909 to 1915. In 1916, he unsuccessfully sought the Republican nomination for president of the United States.

See also **Nobel Prizes** (picture).

Root, John Wellborn (1850-1891), was one of the most important American architects of the Chicago School. The school was an influential group of architects trained in Chicago during the late 1800's. Root became a leader in the aesthetic and technical development of modern office skyscrapers.

Root gained acclaim for the skyscrapers he designed in Chicago with Daniel Hudson Burnham. The two formed a famous partnership in 1873. Their first important project was the 10-storey Montauk Block office building (1881-1882). One of their most influential designs was the Rookery office building (1885-1888). Root designed the structure to resemble a hollow square. Masonry walls supported the exterior while the walls around an interior court were supported by a light iron frame. Root's Rand McNally building (1889-1890) was the first to have an all-steel frame, a structural element that became basic to modern design. Root also designed the 22-storey Masonic Temple (1890-1892), which was the world's tallest building for a time. Root was born in Lumpkin, Georgia.

See also **Architecture** (Early modern architecture in America); **Burnham, Daniel Hudson.**

Root canal therapy. See **Teeth** (Dental decay).

Roots. See **Haley, Alex; Television** (Recent developments).

Rope consists of strands of yarn or wire that have been twisted together. It ranges in size from 4.8 millimetres to more than 152 millimetres in diameter. Rope that is less than 4.8 millimetres thick is called *twine* or *cord. Cordage* is the general term for rope, twine, or cord made from yarn.

People have made and used ropes since prehistoric times. Today, ropes are used for lifting loads, for towing, and for many other purposes. There are three kinds of rope, depending on the material from which they are made: (1) natural-fibre rope, (2) synthetic-fibre rope, and (3) wire rope.

Natural-fibre rope is made from fibres that come from plants. The natural fibre most widely used in rope is *manila,* a hard fibre taken from the leaf stems of the abacá plant. Abacá grows mainly in the Philippines, and most manila rope is manufactured there. Manila rope has great strength and good resistance to wind, rain, and sun. See **Abacá.**

Other natural fibres used in rope include *sisal* and *henequen.* Sisal comes from the leaves of the sisal plant, which grows mainly in Brazil and eastern Africa. It is a hard fibre that has about 80 per cent of the strength of manila. Henequen is taken from the henequen plant, which grows chiefly in Mexico. Henequen is not as strong as sisal and is used primarily in twine and lower grades of rope. See **Henequen; Sisal.**

In the past, much rope was also made from soft natural fibres, such as *hemp* and *jute.* Today, soft fibres are used mostly in twine and in the art of *macramé.* See **Hemp; Jute; Macramé.**

Synthetic-fibre rope is stronger, lighter, and, in most cases, more flexible than natural-fibre rope. Synthetic fibres have greater resistance to chemical damage and do not rot, as do natural fibres.

The first synthetic-fibre rope was made from *nylon* during World War II (1939-1945) and used for parachute cords and glider towropes. Nylon rope is almost three

times as strong as manila rope. The great elasticity of nylon rope makes it the best rope for towing and anchor lines. Rope made from *polyester* fibres is expensive, but it is the best rope for general use. It has almost the same strength as nylon rope but does not have as much stretch. Polyester rope resists damage from *abrasion* (scraping) and the sun's ultraviolet rays better than any other synthetic-fibre rope. *Polypropylene* rope is about 50 per cent stronger than manila rope but has poor abrasion resistance. Also, special chemical compounds must be added to polypropylene rope to give it ultraviolet resistance.

Manufacturers make extremely strong rope from synthetic fibres called *aramids.* Rope made from aramid fibres can be used under hotter conditions than other synthetic fibres because it has a high melting point. It also resists stretching.

Manufacturers also produce ropes that combine the desirable features of two or more synthetic fibres. A common combination—polyester and polypropylene—provides a cheaper substitute for polyester.

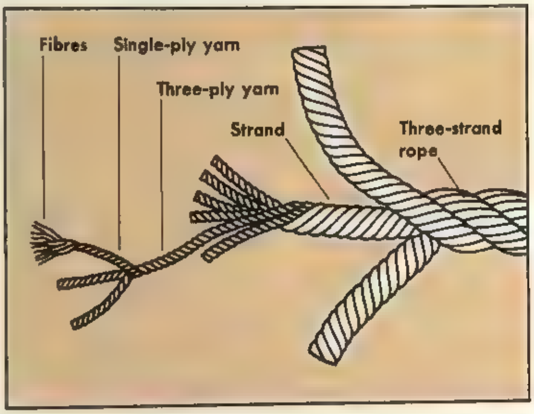
Wire rope consists of steel wires twisted together. It is stronger and wears better than most fibre rope, but it is much heavier and not as flexible as rope made from fibres. Wire rope, often called *cable,* is used in operating such equipment as lifts, oil well derricks, and shovels used in construction work.

How rope is made. Ropes must be carefully designed to meet such usage requirements as abrasion resistance, chemical and ultraviolet resistance, strength, stretch, and weight. Rope manufacturers buy bales of natural fibres from fibre brokers. A machine called a *card* combs the fibres and lays them parallel, forming a continuous ribbon. The ribbon is drawn out until it is thin enough for spinning. A machine spins the ribbon into yarn, and strands are made by twisting together two or more yarns. Three or more strands are *laid* (twisted) together to form rope.

Manufacturers buy most synthetic fibres in *filament* form. A machine called a *twister* twists the long filament yarns into *plied yarns,* which are then made into rope in the same way as natural fibre yarn.

Parts of a three-strand rope

Rope consists of many fibres that have been spun into yarns. The yarns are then twisted into thick strands. The most common type of rope has three strands *laid* (twisted) together.



Most rope has three strands, but four- and eight-strand ropes are also popular. Another common type, called *cable-laid rope,* consists of three three-strand ropes *closed* (wrapped) together.

Manufacturers make wire rope by twisting a number of wires together to form strands and then closing the strands around a core. The strongest wire ropes have wire cores.

See also **Century plant**; **Cowboy** (His rope); **Fibre**; **Knots, hitches, and splices**; **Oakum.**

Rorke's Drift. See **Anglo-Zulu War.**

Rorqual. See **Whale** (Rorquals).

Rorschach test. See **Mental illness** (Methods of treatment; picture).

Rosamund (1140?-1176?) was the mistress of Henry II of England. She was the daughter of Walter, Richard

Some uses of rope

Rope has a wide variety of uses. Window cleaners hang their scaffold with manila rope, which comes from the fibres of the abacá plant. Nylon rope is widely used as *mooring line* to tie ships and boats to docks. Wire ropes secure the cables of huge suspension bridges.

Manila rope

Nylon rope

Wire rope

FitzPonce's son, who acquired Clifford Castle, near Hereford, and assumed the surname Clifford. Her full name was Rosamund Clifford. She is generally called "Fair Rosamund" in the many legends about her life. According to one story, Henry's wife, Eleanor of Aquitaine, poisoned her out of jealousy.

Rosario (pop. 1,079,359) is the third largest city in Argentina. Only Buenos Aires and Córdoba have more people. Rosario lies on the Paraná River, in east-central Argentina (see **Argentina** [political map]). The city is a major inland seaport and an important industrial centre in Argentina.

Rosario was founded in 1730 on the eastern edge of the *Pampa,* a huge fertile plain. The city first became important in the late 1800's, when farmers on the Pampa began producing large quantities of agricultural products. Rosario's location on the Paraná River made it an ideal point from which to ship the products to places outside the region. Today, five railway systems and five major highways link various parts of northern and central Argentina to Rosario's excellent port facilities. Many factories in Rosario produce processed foods from farm products. Other industries include petroleum refining and the manufacture of chemicals, metal products, and textiles. Rosario is modern in appearance and has many boulevards and attractive parks.

Rosary is a string of beads used as an aid to memory and concentration while praying. The beads may be made of wood, metal, or stone. The rosary commonly used by Roman Catholics consists of 50 small beads divided into equal sections by four large beads and a pendant. The pendant, composed of two large beads, three small ones, and a crucifix, hangs from the rosary. Worshippers recite the Lord's Prayer on the large beads. They use the small beads for prayers known as "Hail Marys," in which they ask the Virgin Mary to pray to God for them. At the end of each group of Hail Marys, a short verse in praise of God is recited. The Apostles' Creed is recited on the crucifix. While worshippers recite the prayers, they are expected to reflect on the mysteries of the faith.

Prayer beads are of ancient origin and were probably first used by Buddhists in an attempt to combine vocal prayer with mental prayer. Buddhists, Hindus, and Muslims use them in certain forms of their prayers. Early forms of praying with a rosary began in Christianity during the Middle Ages, but became widespread only in the 1400's and 1500's.

Rosas, Juan Manuel de. See **Argentina** (Forming a national government).

Roscius, Quintus (126? B.C.-62? B.C.), a Roman actor, was so famous in his day that his name came to stand for "great actor." He excelled in both tragic and comic parts. He founded a school for actors and wrote a book on acting and speaking. One of his admirers was the orator Cicero, who defended him in a famous speech. Quintus Roscius Gallus was born near Rome and became rich through his acting.

Roscommon is a county in the province of Connacht in the western part of the Republic of Ireland. It is an agricultural region. Roscommon town is the largest town.

People and government. The population of Roscommon has been declining as a result of emigration since the mid 1800's. The number of people now is less than one-third of that in 1850. Less than one-fifth of the population lives in urban areas.

Roscommon is an inland county in the Republic of Ireland. It is one of five counties in the province of Connacht.

The proportion of people who are Roman Catholic, at 97 per cent, is the highest of any Irish county. Those of other religions are almost all members of the Church of Ireland.

Roscommon is a combined constituency with Longford, which elects four members of parliament to *Dáil Éireann* (the lower house of parliament). Local government is by a county council, which is based in Roscommon town.

Economy. A greater proportion of Roscommon's people work in agriculture than in any other Irish county. In the south and centre, the land is more fertile and farms larger than in most of Connacht.

The rearing of beef cattle is by far the most important farming activity. Sheep are also important, especially in the south. The farming is largely pastoral, with only 2 per cent of the land used for arable crops, mainly barley, oats, and potatoes.

Only a quarter of people work in the manufacturing industry. The main centres are Ballaghaderreen, Boyle, and Roscommon. The main types of manufacturing are food processing, engineering, and metal industries.

Various service industries account for two-fifths of employment. The leading service sector is the retail trade through the shops of the county. Other important services include catering, community services, education, finance and banking, and health care.

The main roads in Roscommon are those which pass through it linking Dublin with Galway, Mayo, and Sligo. The national primary roads are the N6 in the south, and

Facts in brief about Roscommon

Population: *1991 census*—51,876.
Area: 2,463 km².
Largest towns. Roscommon, Boyle, Castlerea, Ballaghaderreen.
Chief products: *Agriculture*—cattle, milk, pigs, sheep, timber. *Manufacturing*—building materials, chemicals, clothing, engineering goods, food products.
Origin of name: From the Irish *Ros Comain* (St. Coman's wood).

Clonalis House is a beautiful Georgian house at Castlerea in County Roscommon. It is open to the public and attracts many visitors each year.

the N5 and N4 in the north. The N61 road links the county from north to south. There are railways from Athlone to Galway and Mayo, and through Boyle to Sligo.

Land. The River Shannon and its lakes, principally Lough Ree, form the county's eastern boundary. They separate Roscommon from the counties of Leitrim, Longford, Westmeath, and Offaly. The Shannon tributary, the River Suck, forms much of the southwestern boundary with Galway. Mayo is to the west and Sligo to the northwest.

Roscommon is almost entirely a limestone lowland. The limited areas of upland are in the extreme north. The Curlew Mountains along the Sligo border are sandstone. The Arigna area is part of a shale and sandstone plateau which is mainly in Leitrim.

In the south of Roscommon, the limestone is at or near the surface. Much of the land is dry and there are many stone walls. In the north the soil is much deeper, and in places it is shaped into the small rounded hills called *drumlins*. There are peat bogs in poorly drained areas throughout the county.

The annual rainfall in Roscommon is about 100 centimetres. Average temperatures are 4° C in January and 15° C in July.

History. Rathcroghan, near Tulsk, was the ancient seat of the kings of Connacht. The main families in the county were the O'Connors and MacDermotts in the north, and the O'Kellys in the south. There are remains of a fine medieval Cistercian monastery at Boyle and a castle at Roscommon.

English troops, led by Oliver Cromwell, invaded Ireland in 1649. Many people lost their homes in other parts of the country and moved to Roscommon. Population loss at the time of the Great Famine in the 1840's was greater than in any other Irish county. One third of the people died or emigrated. Douglas Hyde, first president of Ireland, was born in Roscommon.

See also **Connacht; Ireland, History of; Shannon, River.**

Rose is one of the most beautiful of all flowers. It is a symbol of fragrance and loveliness. Roses come in many colours, including various shades of pink, red, yellow, and white. Rose growers have not developed a blue rose, but they do grow lavender varieties. Some roses, such as the teas and hybrid teas, smell like tea or fruit. Others have a fragrant "rose" scent, and still others have little odour. Wild roses are native only to the Northern Hemisphere but have been introduced into other parts of the world. Wild roses such as the dog rose and the sweetbrier have single flowers each with five petals only. They make large, thorny shrubs.

Old garden roses mostly flower only around midsummer, though some are *remontant* (flower more than once in a growing season). Most old garden roses have globe or cupshaped blooms with a sweet scent. Their colours range from white, through pale pink to red, maroon and purple. They grow into quite large, straggly bushes.

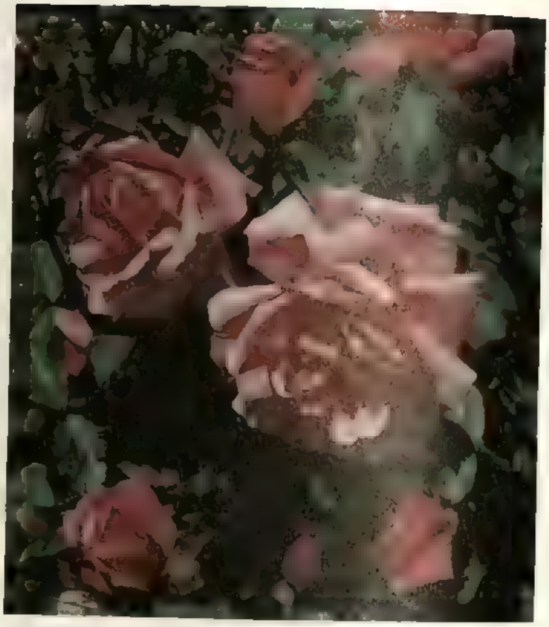
Among the old garden roses, the gallica family is the oldest in cultivation, dating at least from the 1500's and possibly much earlier. The others, with the exception of the china roses, are all descended from the gallicas. The albas probably were brought to western Europe by the Romans. Moss roses are a form of centifolia, or cabbage rose, with a glandular, mossy looking growth on their flower stems and *calyx* (the outer protective part of the flower including the sepal).

The china roses are a particularly important group for they have always been remontant, and it was a rose from China that brought this characteristic to the once-flowering Western varieties. The result of this interbreeding was the bourbon family which, in turn, led to the hybrid perpetuals and hybrid teas.

The most popular garden roses are the *hybrids*—flowers bred from two different varieties. For example, hybrid teas were developed from the everblooming hybrid teas and the hardier hybrid perpetuals. Floribundas were bred from the hybrid teas and polyanthas. Grandifloras, one of the newer kinds of roses, resulted from crossing hybrid teas with floribundas.

The climbing and rambler roses can be trained on trellises and fences. Others creep over the ground and

Hybrid tea roses have only a few flowers on each plant. This popular type of rose includes the peace rose, *above.*



Floribunda roses bear flowers in clusters and thrive with little care. The vogue variety of floribunda is pictured above.

may cover steep banks. Some climbers have large flowers, but true ramblers have clusters of small flowers. Climbers have to be hardy. Those with the small flowers are usually the hardiest.

Another important group is the shrub roses. The group includes the hybrid musk and rugosa families. They grow up to 1.8 metres tall and can be used for hedges. They usually have fragrant flowers. The sweetbrier and its cultivated forms are tall, graceful bushes, with fragrant leaves.

Miniature roses, another popular group, range in height from 20 to 40 centimetres. Some have flowers little more than a centimetre across.

Roses grow in many parts of the world, in various soils and climates. They do especially well in temperate and mild climates. Roses thrive under cultivation, and thousands of varieties have been developed.

Popular roses. Of the thousands of different varieties of roses, some are popular year after year. Others disappear because plant breeders produce better ones.

The following list gives some popular varieties of roses and the colours of their flowers:

Old Garden Roses. Celestial (Alba), blush-pink; Charles de Mills (Gallica), crimson; Fantin Latour (Centifolia), blush-pink; Mme Hardy (Damask), white; Old Blush (China), pink

Hybrid Teas. Alexander, vermilion; Congratulations, soft rose-pink; Freedom, yellow; Just Joey, coppery-orange; Peace, soft yellow

Floribundas. Anne Harkness, buff-orange; City of Leeds, salmon-pink; Escapade, rosy-violet; Evelyn Fison, scarlet; Iceberg, white

Climbers. Dublin Bay, crimson; Golden Showers, yellow; Handel, cream edged red

Ramblers. Albéric Barbier, creamy white; François Juranville, salmon-pink; Seagull, white

Modern Shrub Roses. Constance Spry, pink; Golden Wings, yellow; Scabrosa, mauve-pink

Miniatures. Bit o' Sunshine, yellow; Red Ace, red; Starina, orange-red

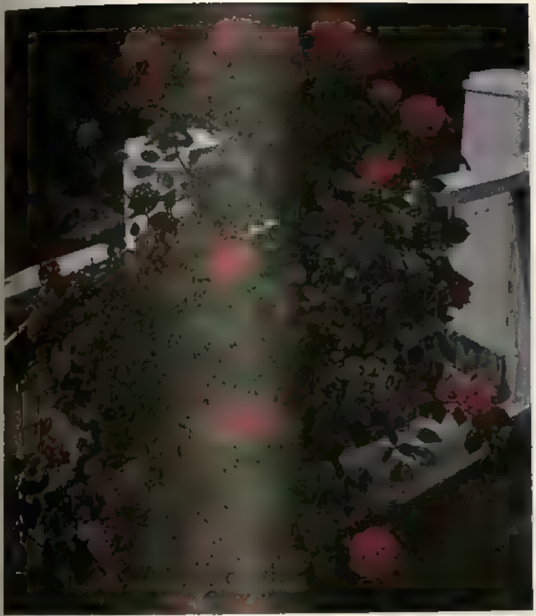
How to grow roses. A completely new variety of rose is grown from seed. Seeds are formed in the hips as the result of transferring the pollen of one variety onto the stigmas of another. The seedling rose is then budded or bud-grafted onto the roots of selected wild roses. These wild roses are known as rootstocks and they give the new rose qualities such as added vigour. All the roses sold by nurseries are produced by this method. Growing roses from cuttings is a much slower process and is only used commercially with miniature roses.

The plot for a rose garden should be protected from cold winds and open to sunlight several hours a day. A deep, rich loam is usually the best soil for roses. But hybrid roses will grow in sandy and gravelly soil. Any soil must be well drained. Roses do not grow well in wet ground. Sometimes they need artificial drainage.

A few weeks before planting, the soil should be mixed with about one-third its bulk of well-rotted manure to a depth of 60 centimetres. Fresh manure should not be used as it may injure rose roots.

The time for planting depends on the kind of rose and on the location. Some hardy roses can be planted in autumn, but the general rule is to plant in the spring.

After the plants are received from the nursery, do not let the wind dry out the roots before they are planted. If necessary, cover them with sacking or similar material, and keep them damp. The holes should be deep enough to let the roots point downward and slant outward. The roots must not lie flat. Arrange the plants so that the beds are easy to water and weed. A good rule is to have the beds not over 1.5 metres wide. The plants should be from 45 to 75 centimetres apart. The exact distance depends on their spreading habits. A garden fork



Climbing roses develop long stems. Such climbers as the blaze rose, *above,* may fasten to fences or other supports.

Gallica roses are the largest group of old garden roses and the closest in appearance to the wild rose.

and a sharp steel rake should be used to keep the soil loose and the weeds out. However, plants should not be cultivated deeply.

Pruning will have to be carried out in late spring to encourage the formation of strong new shoots, which are the ones that bear the best flowers. After pruning, about a handful of rose fertilizer per bush should be sprinkled onto the beds round the roses. *Suckers* (shoots coming from the rootstock rather than the cultivated variety) should also be removed or they will gradually take over the whole rose. If in doubt as to their identity, trace them to their source. If they originate below the budding union, they will be suckers and should be pulled away, not cut.

The rose family is one of the largest and most important families of flowering plants. There are about 3,400 species of trees, shrubs, and herbs in the rose family. Members of the family include plants that produce such fruit as apples, pears, berries, peaches, apricots, plums, and cherries. The rose family's many ornamental plants include the meadowsweet, mountain ash, and hawthorn. Plants of this family also give us many useful products. Several fine woods are used in cabinetmaking. Attar, an oil from rose petals, is used to make toilet water and perfumes (see **Attar; Rose water**). The fruit of some rose plants, called *hips,* are sometimes used in jam and other foods. Rose hips are rich in vitamin C.

Plants of the rose family have regular flowers. Each flower has five petals, a calyx with five lobes, many stamens, and one or more carpels. These plants bear seeds, and so they are classed as *angiosperms.* When the seeds *germinate* (begin to develop), they have two seed leaves, called *cotyledons.* Rose plants and other angiosperms that bear cotyledons are classified as *dicotyledons,* or *dicots.*

Scientific classification. Roses belong to the rose family, Rosaceae. They make up the genus *Rosa.* Botanists disagree on how to divide them into species. Estimates of the number of species range from 30 to 250.

Related articles in *World Book* include:

Angiosperm	Crab apple	Mountain ash
Apple	Eglantine	Peach
Apricot	Flower (picture: Garden perennials [Flowering shrubs])	Pear
Attar	Hawthorn	Plum
Bramble	Loquat	Quince
Cherry		Raspberry
Cinquefoil		Spiraea
		Strawberry

Rose, Ernestine Potowski (1810-1892), was a leading reformer in the United States during the mid-1800's. She became especially known as an early supporter of efforts to obtain equal rights for women.

In the 1840's, Rose led a campaign in New York for legislation permitting women to keep control of property they had owned before marriage. Laws of the day gave their husbands control of such possessions. The state legislature passed the bill in 1848. Rose then became active in the new women's rights movement (see **Women's movement** [The beginnings of women's movements]).

Rose was an excellent orator. She addressed women's rights conventions and state legislatures. She also worked to abolish slavery and to end the manufacture of alcoholic beverages. In 1869, she joined Susan B. Anthony and Elizabeth Cady Stanton in founding the National Woman Suffrage Association, which campaigned for women's right to vote.

Ernestine Potowski was born in Piotrków (now Piotrków Trybunalski), Poland. She and her husband, William E. Rose, a British silversmith, settled in the United States in 1836. The Roses moved to England in about 1870.

Rose, Lionel (1948-), an Australian Aboriginal boxer, became world bantamweight champion in 1968. He defeated the Japanese boxer Masahiko "Fighting" Harada on points in the fight for the title in Tokyo. It was Rose's 16th consecutive win and brought his total to 28 victories out of 30 professional bouts. He lost his title to the Mexican Ruben Olivares in Mexico in 1969.

Lionel Rose

Rose was born in the Gippsland area of Victoria. He was the oldest of nine children. When his father died in 1964, Rose became a professional boxer to support his family. He won the Australian bantamweight title by a points decision from Noel Kunde in 1966. It was his 20th paid contest. In 1967, he successfully defended his title with a 13th round knockout over Rocky Gattellari.

Rose chafer is a beetle about 8 millimetres long. It is light brown, and has long, spiny legs. It feeds on many plants and is often found on roses, ornamental plants, grapes, and various fruit trees. The beetles eat the blossoms of grapes and roses, and often apples. They also attack many fruits. The rose chafer is particularly destructive in localities where there are large areas of grassland. It lives throughout the eastern and central regions of the United States.

Scientific classification. The rose chafer belongs to the scarab beetle family Scarabaeidae. It is classified as *Macrodactylus subspinosus.*

See also **June beetle**.

Rose of Jericho. See **Resurrection plant**.

Rose of Lima, Saint (1586-1617), was the first person born in the Western Hemisphere to be *canonized* (declared a saint) by the Roman Catholic Church. She was canonized in 1671. She was born in Lima, Peru. In 1606, Rose joined the Dominican religious order. She ran an infirmary for poor children and old people in the garden of her home. She was loved by people from all of Lima's social classes.

Rose practised extreme mortification and penance and was gifted with remarkable mystical experiences and visions. She is the Patroness of South America. August 30 is her feast day.

Rose of Sharon. See **Hibiscus**.

Rose water is a clear, colourless solution made from fresh rose flowers and used in making perfumes and certain medicines. Rose water has a fragrant odour much like that of fresh rose blossoms. It is made by distilling the fragrant parts of the flowers, such as the petals and sepals, with water. This is done by placing the flowers in water, boiling the water, and separating the vapour into a vessel. The vapour is then condensed back into a liquid, which is rose water.

Roseau (pop. 11,000) is the capital and largest city of Dominica, an island country in the Caribbean Sea. The city lies on the southwestern coast of the island, at the mouth of the Roseau River.

Roseau has a busy port whose import and export activities are the basis of the city's economy. The city includes modern commercial buildings as well as stone structures dating from the 1700's. Many of Roseau's people live in small wooden or cement-block houses.

Roseau was founded in the mid-1700's by French settlers. They named the site *Roseau,* which means *reed* in French, because reeds grew there. From the 1600's to 1759, France and Great Britain struggled for control of Dominica. Britain ruled the country from 1759 to 1978, when Dominica gained independence. In 1979, a hurricane struck Roseau, causing several deaths and extensive damage to the city.

Rosebery, Earl of (1847-1929), was Prime Minister of Britain in 1894 and 1895. A Liberal, he had previously been Foreign Secretary under William Gladstone in 1886 and again from 1892 to 1894.

Archibald Philip Primrose was born in London and educated at Eton and Oxford University. While at the university, he bought a racehorse. His college authorities told him that he was not allowed to own a racehorse. Rather than give up the horse, he left the university without a degree. In 1868, Primrose succeeded his grandfather as Earl of Rosebery. In 1889, Rosebery became the first chairman of the London County Council.

After Gladstone retired as Prime Minister in 1894, Queen Victoria chose Rosebery to succeed him. Three months later, Rosebery's horse *Ladas* won the Derby.

Rosefish is an important food fish found from Iceland to the United States and off the northern shores of Europe, ranging as far north as the Arctic Sea. A deepwater fish, it comes to the surface at night to feed off smaller fish and crustaceans. The rosefish has an orange-red colour, a spiny head, and may grow 80 centimetres long. It is also called *Norway haddock.*

Scientific classification. The rosefish is in the family Scorpaenidae. The North Atlantic rosefish is *Sebastes marinus.*

Rosella is the name given to several types of Australian parrots. The name comes from Rose Hill, where these parrots were first seen. *Eastern rosellas* live in eastern and southeastern Australia. They are bright red,

A rosella has brightly coloured feathers. The eastern rosella, *above,* lives in eastern Australia.

yellow, and blue. They eat seeds and fruit and often damage farm crops. They make their nests in hollow trees and lay from four to seven eggs.

Scientific classification. The rosella belongs to the family Psittacidae. The eastern rosella is *Platycerus exemius.*

Rosemary is an evergreen shrub of the mint family noted for the fragrance of its leaves. Rosemary grows wild in the Mediterranean region and measures from 60 to 180 centimetres high. It bears shiny, dark-green leaves and small, pale-blue flowers. In masses, blossoming rosemary looks like blue-grey mist blown inland from the sea. Its name comes from the Latin word *rosmarinus,* meaning *sea dew.*

Rosemary is used fresh or dried as an herb for seasoning. The plant yields an oil used in perfumes. The dried leaves have been used in *sachets* (small bags of perfumed powder), as a moth repellant, and to brew tea to soothe stomachaches and headaches. Rosemary has long been a symbol of remembrance. Europeans carried rosemary at weddings and funerals because they believed it would aid their memories.

Scientific classification. Rosemary belongs to the mint family, Labiatae (Lamiaceae). Its scientific name is *Rosmarinus officinalis.*

Rosenberg, Alfred (1893-1946), was the philosopher of the German Nazi movement. His *Myth of the Twentieth Century* (1930) stressed "Aryan" racial superiority and the cult of the great leader. He wanted to replace Christianity with a Germanic pagan religion. Born of German parents in Estonia, he returned to Eastern Europe during World War II (1939-1945) as minister for Germany's eastern occupied territories. He pressed for extermination of the Jews. After the war, he was executed for war crimes.

Rosenberg, Julius and Ethel, were American citizens, husband and wife, who were executed for spying for the Soviet Union during World War II (1939-1945). They became the first United States civilians ever put to death for wartime spying.

Julius and Ethel Rosenberg, husband and wife, were U.S. citizens executed as spies in 1953. They were convicted of giving atomic bomb secrets to the Soviet Union during World War II.

Julius Rosenberg (1918-1953) and Ethel Greenglass Rosenberg (1915-1953) were born and raised on the Lower East Side of New York City. They were married in 1939. By that time, both of them had been involved in radical political activities. In 1940, Julius began working for the U.S. Army Signal Corps as a civilian junior engineer. Early in 1945, the Army fired him for being a Communist. Between 1946 and late 1949, Julius worked with Ethel's brother David Greenglass in a small machine shop they owned in New York City. In 1944 and 1945, Greenglass had worked as a machinist at Los Alamos, New Mexico, on the U.S. project to make an atomic bomb.

In 1950, Greenglass was arrested for spying for the Soviet Union while working at Los Alamos. The U.S. government charged that the information he supplied was used to build the first Soviet atomic bomb. Greenglass claimed Julius had recruited him to collect the information. As a result, the Rosenbergs were arrested and accused of passing on to the Soviet Union the secret atomic-bomb information that Greenglass had supplied. The Rosenbergs pleaded innocent.

In 1951, a jury found the Rosenbergs guilty of conspiracy to commit espionage. Judge Irving Kaufman sentenced the Rosenbergs to die in the electric chair. Protests against the conviction and sentence were organized in the United States and Europe. Numerous people felt that the Rosenbergs did not get a fair trial or that their sentence was too harsh. Many respected people, including the great scientist Albert Einstein and Pope Pius XII, urged clemency. The case was sent on appeal to the Supreme Court of the United States, but the court denied all appeals. President Dwight D. Eisenhower twice rejected pleas for clemency. The Rosenbergs were executed in 1953 at Sing Sing prison in Ossining, New York. Greenglass was sentenced to 15 years in prison. He was released in 1960.

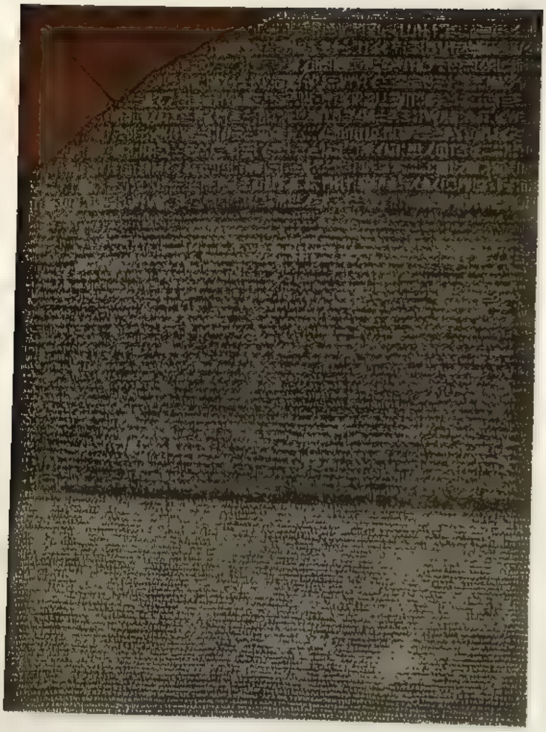
Roses, Wars of the. See Wars of the Roses.

Rosetta stone gave the world the key to the long-forgotten language of ancient Egypt. A French officer of Napoleon's engineering corps discovered it in 1799. He found the stone half buried in the mud near Rosetta, a city near Alexandria, Egypt. The Rosetta stone was later taken to England, where it is still preserved in the British Museum in London.

On the stone is carved a decree by Egyptian priests to commemorate the crowning of Ptolemy V Epiphanes, king of Egypt from 203 to 181 B.C. The decree is in both Egyptian and Greek. The first inscription is written in ancient Egyptian hieroglyphics. The second is in the demotic script that was the popular form of writing in Egypt at that time. At the bottom of the stone the same message is written again in Greek. See Hieroglyphics.

The stone is made of black basalt, 28 centimetres thick. It is about 115 centimetres high and 70 centimetres across. Part of the top and a section of the right side of the Rosetta stone are missing.

The language of ancient Egypt had been a riddle to scholars for many hundreds of years. The Rosetta stone solved the riddle. A French scholar named Jean François Champollion studied the stone. Using the Greek text as a guide, he studied the position and repetition of proper names in the Greek text and was able to pick out the same names in the Egyptian text. This enabled him to



The hieroglyphics on this fragment of stone, known as the Rosetta stone, were translated by scholars. They provided the key to the language used in ancient Egypt.

learn the sounds of many of the Egyptian hieroglyphic characters.

Champollion had a thorough knowledge of Coptic, the last stage of the Egyptian language that was written mainly with Greek letters. This knowledge enabled him to recognize the meanings of many Egyptian words in the upper part of the inscription. After much work, Champollion could read the entire text. In 1822, Champollion published a pamphlet, *Lettre à M. Dacier,* containing the results of his work. This pamphlet enabled scholars to read the literature of ancient Egypt.

Rosewall, Ken (1934-), first played Davis Cup tennis for Australia at the age of 19. He retired from first class tennis in 1979. Kenneth Robert Rosewall was born in Sydney. Although he was ranked at his peak as a top world player, with one of the best backhands in tennis history, he never won a Wimbledon championship. He reached the finals in 1954, 1956, 1970, and 1974, but lost each time. He played his last final at the age of 39. He did win the three other major titles—the Australian Open, in 1953, 1955, 1971, and 1972; the French Open, in 1953 and 1968; and the United States Open, in 1956 and 1970.

Rosewood is the name of several kinds of wood of the botanical genus *Dalbergia.* It is used as solid wood or as veneer in making ornamental furniture and musical instruments. Its ability to take a high polish and its rich colour make rosewood valuable. Its colour runs from dark reddish-brown to purplish-brown. Its name comes from the roselike odour of the wood when it is cut up. It is sometimes called *blackwood.* Rosewood grows in Brazil, Central America, Southern Asia, and Madagascar.

Scientific classification. Rosewood is in the pea family, Leguminosae (Fabaceae). It is genus *Dalbergia.*

Rosh Ha-Shanah is the Jewish New Year celebration. The Hebrew words *Rosh Ha-Shanah* (which are also written *Rosh Hashanah*) mean *Beginning of the Year.* During this solemn religious festival, Jews pray for God's forgiveness, for a good year, and for long life. Rosh Ha-Shanah usually begins in September, on the first day of the Hebrew month of Tishri, and lasts two days. Many Reform Jews celebrate it for one day.

Rosh Ha-Shanah begins the Ten Days of Penitence, which end on Yom Kippur, the Day of Atonement (see **Yom Kippur**). Jews believe Rosh Ha-Shanah is the beginning of God's annual judgment of humanity. At that time, God decides who will continue to live and who will die during the coming year.

Jews attend synagogue services on Rosh Ha-Shanah. These services emphasize the themes of judgment, penitence, and forgiveness. A ram's horn, called a *shofar,* is blown to call for repentance and to remind people of current issues that affect Jews. Three special groups of prayers are recited during the holiday. The first group reminds the people that God rules the world. The second group tells them that God responds to the sound of the shofar, and the third group that He remembers people's deeds.

See also **Judaism** (The High Holidays).

Rosicrucian Order is an international nonsectarian fraternity that studies the higher principles of life, and claims to possess wisdom handed down from ancient times. Members learn about philosophy and the arts and sciences.

The origins of the brotherhood are unknown. A document called *Account of the Brotherhood* was first published in 1614, and describes the journeys of a founder of the organization who may have lived in the 1400's, and is said to have lived for 106 years. A Swiss alchemist named Philippus Paracelsus, who died in 1541, is also believed by some to have been the founder of the Rosicrucian Order.

Today, Rosicrucians study trends of history and attempt to apply their philosophy to meeting life's problems. Members believe that people must understand and live in harmony with nature. The Rosicrucian Order is not a religion.

The full name of the order is the *Ancient Mystical Order Rosae Crucis.* Its emblem is a gold cross with a red rose in the centre, symbols of Christ's resurrection and redemption.

See also **Paracelsus, Philippus.**

Rosin is resin derived from several varieties of North American and European pine trees. It ranges in colour from pale yellow to dark brown and dark red. There are three main types of rosin. *Gum rosin* is produced by distilling resin collected from living trees. The crude resin is obtained from the trees by making lengthwise cuts in them. The resin then flows from the cuts. *Wood rosin* is extracted from tree stumps with the use of solvents. *Sulphate rosin,* also called *tall oil rosin,* is a by-product of the manufacture of wood pulp.

Rosin is used for a variety of industrial purposes. It is most commonly used with sodium carbonate or sodium hydroxide solution to *size* (coat) paper. The sizing helps keep the paper from absorbing moisture. Rosin is also

used in the preparation of paints, varnishes, adhesives, sealants, and printing inks.

See also Resin.

Ross, Barnaby. See Queen, Ellery.

Ross, Betsy (1752-1836), was an American seamstress who made flags in Philadelphia at the time of the American Revolution. Some people believe that she made the first American flag that had stars and stripes.

Betsy Ross was born in Philadelphia, the daughter of Samuel Griscom, a Quaker carpenter. She is believed to have attended the Friends School. In 1773, she eloped with John Ross, an upholsterer. Soon afterward, Ross was killed. Mrs. Ross took over his shop, and became known as an expert seamstress.

William J. Canby, a grandson of Betsy Ross, wrote a paper about her in 1870. Canby said that when he was 11, his 84-year-old grandmother told him the story of how she made the first official United States flag. As the story goes, a committee visited Mrs. Ross in June 1776. George Ross, a signer of the Declaration of Independence and an uncle of Betsy Ross's first husband, was a member of the committee. These men asked Mrs. Ross to make a flag according to the rough design they gave her. Washington wanted six-pointed stars in the flag, but the seamstress persuaded him to make the stars five-pointed.

No proof has been found that this incident actually happened. But it is known that Betsy Ross was an official flagmaker for the Pennsylvania Navy. The stars-and-stripes design she may have sewn was adopted by Congress on June 14, 1777.

Ross, Sir James Clark (1800-1862), was a British polar explorer. He led an expedition to the Antarctic from 1839 to 1843 and discovered the Ross Ice Shelf, Victoria Land, and Mount Erebus, an active volcano. He reached 78° 10' south latitude, the southernmost point reached by any person until 1900. His uncle, Sir John Ross, and Sir William Edward Parry trained him during six Arctic voyages in search of the Northwest Passage between 1818 and 1834. Ross discovered the north magnetic pole in 1831 while serving under his uncle. Ross was born in London.

Ross, Sir John (1777-1856), led a British expedition in 1818 to seek a northwest passage to Asia. Commanding the *Isabella*, he sailed into Baffin Bay as far as Lancaster Sound, but turned back, thinking that mountains blocked his way. In 1829, he led a second expedition, but again failed. On this expedition, he surveyed the Gulf of Boothia, the Boothia Peninsula, and King William Island. Ross was born in Inch, Dumfries and Galloway Region, Scotland. He joined the navy at the age of 9 and rose to admiral. See also **Arctic Ocean.**

Ross, Sir Ronald (1857-1932), a British doctor, won the 1902 Nobel Prize for physiology or medicine for work that led to the discovery of how to combat malaria. In 1894, Ross began research to prove Scottish doctor Sir Patrick Manson's theory that malaria was transmitted by mosquitoes (see **Manson, Sir Patrick**). After searching for two years, Ross found the malaria parasite in the stomach of a mosquito that had bitten a malarial patient. In 1898, he succeeded in transmitting bird malaria by mosquito bites. In 1900, scientists used human volunteers and confirmed Ross's belief that the *Anopheles* mosquito carried human malaria.

Ross was born in Almora, India. He studied medicine in England but did most of his research in India.

Ross and Cromarty (pop. 49,953) is a local government district in Highland Region, Scotland. Its beautiful mountain scenery attracts many tourists. Farmers in the district raise cattle and sheep. Whisky distilling is a long-established industry. Modern industries include those associated with North Sea oil development. Dingwall is the district's administrative centre. See also **Highland Region.**

Ross Dependency is a wedge-shaped section of Antarctica that includes Ross Sea, Ross Ice Shelf, and McMurdo Sound. It covers about 414,400 square kilometres of land area, and about 337,000 square kilometres of permanent ice shelf. It is uninhabited except for scientific personnel located at Scott Base. New Zealand has been responsible for the administration of the area since 1923.

Rosse, Earl of (1800-1867), was an Irish astronomer who built a reflecting telescope, at that time the largest and most powerful in the world. He spent several years perfecting the methods and materials used to construct the telescope's mirror of polished metal. The telescope stood in the grounds of Rosse's family home at Birr Castle, in County Offaly. With the telescope, Lord Rosse made detailed observations of the heavens. In particular, he studied the hazy masses called *nebulae*.

William Parsons was born in York and became the third Earl of Rosse in 1841. He was educated at Trinity College, Dublin, and at Magdalen College, Oxford. In

The third Earl of Rosse, a famous astronomer, lived at Birr, in County Offaly, Ireland, where this statue now stands.

1823, he was elected member of Parliament for King's County (now Offaly).

See also **Astronomy** (History).

Rossendale (pop. 64,000) is an English local government district in southeast Lancashire, on the western edge of the Pennine Hills. Much of the district consists of open moorland, on which sheep and cattle graze. The towns of Bacup, Haslingden, Rawtenstall, and Whitworth are located in the steep valleys between the upland areas. The main industries include light engineering, and production of cotton textiles, felt, footwear, and plastics. See also **Lancashire.**

Rossetti, Christina Georgina (1830-1894), was an English poet. Many of her poems are melancholy and deal with symbolic religious themes. But one of her best works is the nonreligious "Goblin Market" (1862). Rossetti wrote it in an exciting, fast-paced style that makes the poem particularly effective when read aloud. Her other works include *Sing-Song* (1872), a collection of nursery rhymes; and two volumes of religious prose—*Annus Domini* (1874) and *Seek and Find* (1879).

Rossetti was born in the city of London. She was the sister of Dante Gabriel Rossetti.

Rossetti, Dante Gabriel (1828-1882), was a central figure in the Pre-Raphaelite Brotherhood, an art movement he helped found in 1848 (see **Pre-Raphaelite Brotherhood**).

Rossetti's poetry is noted for its flowery language, vivid descriptions, and fantastic and symbolic themes. As a painter, Rossetti produced many works that are noted for their rich colours and attention to detail.

Many of Rossetti's poems and paintings were inspired by Elizabeth Siddal, whom he married in 1860. She died less than two years later, and the grief-stricken Rossetti buried the only manuscript of his poems with her. He agreed in 1869 to have the manuscript removed from her grave, and the collection was published in 1870 as *Poems.* The collection made Rossetti known as a major poet. In 1881, he published *Ballads and Sonnets.* Rossetti's best-known poems include "The Blessed Damozel," "Sister Helen," and a series of love sonnets, *The House of Life.*

Rossetti was born in London. His sister Christina was also a famous poet.

The Wedding of St. George and Princess Sabra (about 1857), a watercolour, Tate Gallery, London

A Rossetti painting is typical of the artist's style in its bright colours and many details. The subject reflects Rossetti's interest in religious and historical themes.

Rossini, Gioacchino Antonio (1792-1868), was an Italian opera composer. His *The Barber of Seville* (1816) is perhaps the greatest farce opera ever written.

Rossini was born in Pesaro and received advanced musical training in Bologna. His second opera, *La Cambiale di matrimonio* (1810), made him an important force in Italian music. This was the first of his operas to be performed. For the next 13 years, Rossini wrote comic and tragic operas, sometimes as many as three or four a year. The most popular ones include *The Italian in Algiers* (1813), *The Turk in Italy* (1814), *Otello* (1816), *Cinderella* (1817), *Moses in Egypt* (1818), *The Lady of the Lake* (1819), and *Semiramide* (1823). They are noted for their rich and catchy melodies, surging vitality, and expert vocal writing. Rossini composed many of the great female roles in his tragic operas for his first wife, Isabella Colbran.

In 1824, Rossini moved to Paris, then the opera capital of the world. In 1826 and 1827, he revised two of his Italian operas for French words. He then composed—to French texts—the masterly comic *Le Comte Ory* (1828) and his serious masterpiece *William Tell* (1829), with its well known overture.

Rossini composed no operas after 1829, partly because he was often in poor health, and partly because he did not like the new operatic styles. His compositions after that year include the religious work *Stabat Mater* (1842) and many small instrumental and vocal pieces that he called *Péchés de vieillesse (Sins of Old Age).* Rossini had intelligence, wit, and humour, and became a famous host while living in Paris.

See also **Opera** *(Barber of Seville, The).*

Rosson, Isabella, was a convict who is recorded as being the first schoolteacher in Australia. She taught her first class in a hut in Sydney in 1789. On September 5 of that year, Isabella Rosson married William Richardson, who was also a teacher. In 1793, Richard Johnson erected Australia's first school building, on the corner of Castlereagh and Hunter streets in Sydney. William Richardson was appointed master.

Rostand, Edmond (1868-1918), was a French playwright best known for his fourth play, *Cyrano de Bergerac* (1897). Rostand called the play a "heroic comedy." It is set in the 1600's and tells the touching story of Cyrano, a swashbuckling poet who has a long, ugly nose. Because of his appearance, he is ashamed to woo the beautiful woman he loves. Instead, he writes letters to her signed by a handsome young friend who also loves her. The woman falls in love with the young man through the letters, not knowing that Cyrano is the true author.

Rostand's dramas were unusual for his time. He wrote romantic plays in verse during a period when most dramatists preferred a style known as *naturalism.* A typical naturalistic play is extremely realistic, pessimistic, and written in prose. Rostand's first play *Les Romanesques* (1894), is a charming story of young love. Edmond Eugene Alexis Rostand was born in Marseille.

See also **Cyrano de Bergerac, Savinien de.**

Rostock (pop. 242,729) is a German seaport and industrial centre on the Baltic Sea. For location, see **Germany** (political map). The city lies at the mouth of the Warnow River and has been an important shipping point for hundreds of years. It is the chief port of entry for Germany's petroleum supplies. Rostock's industries produce machinery, motors, container ships, and cargo ships. A railway ferry runs from suburban Warnemünde to Denmark. Chartered in 1218, Rostock was a member of the Hanseatic League in the Middle Ages (see **Hanseatic League**). The University of Rostock was founded in 1419.

Rostov-on-Don, also called Rostov (pop. 983,000), is one of Russia's most important cities. Rostov (Rostov-na-Donu in Russian) lies on the Don River, 40 kilometres from where it empties into the Sea of Azov (see **Russia** [political map]). The city is the gateway to the Caucasus (see **Caucasus Mountains**). Rostov is a railway and industrial centre and a river port. It has one of the largest farm-machinery plants in Europe. Rostov was founded in 1780. It began a long period of development as a trading centre in the 1800's. During World War II, German forces took control of Rostov in 1942 after a long, bitter battle. They occupied the city until 1943.

Rostropovich, Mstislav Leopoldovich (1927-), is a Soviet cellist. He became the conductor of the National Symphony Orchestra in Washington, D.C. in 1977.

Born in Baku, Azerbaijan, he was taught the cello by his father, a former pupil of Pablo Casals. By the age of ten, Rostropovich was also a competent pianist. In 1940, he made his debut as a cellist in the city of Slavyansk. From 1943 to 1948, he studied at the Moscow Conservatory, partly under Dimitri Shostakovich. Rostropovich won a number of international competitions between 1947 and 1950. He became a teacher at the Moscow Conservatory in 1953, and a professor in 1960. Shostakovich, Profokiev, Britten and other modern composers have written for his grand, expressive playing. Rostropovich left the Soviet Union in 1974 for political reasons.

Rostrum is an Australian organization that encourages the art of public speaking. It has more than 200 clubs in Australia and New Zealand. Sidney F. Wicks, a journalist and author, founded the movement in 1923 at Greendale Farm, Prestbury, near Manchester, England. Several members of the original club introduced the movement to Australia. The first Australian club was founded in Sydney in 1930. In New Zealand, clubs were founded at Wellington and Auckland in 1967.

Roszak, Theodore (1907-1981), was an American sculptor. Roszak became best known for welded metal forms that are violent and expressionistic in appearance. His works in this style frequently deal with menacing, fossilized savage birds and animals. He described these works as "blunt reminders of primordial strife and struggle." Roszak was born in Poznań, Poland, and moved to Chicago with his family in 1909. He studied at the Art Institute of Chicago, the National Academy of Design, and Columbia University. His earliest works were paintings. From 1935 to 1945, he produced sculptured, abstract works, which were severely geometrical and impersonal in style.

Rot is a symptom of many plant diseases in which the plant decays. It is caused by bacteria or fungi that infect the plant and kill its cells. Rot quickly destroys fruits and vegetables, but growers help prevent it by spraying plants with pesticides.

Common diseases that cause rot include *bitter rot, black rot, brown rot, dry rot,* and *potato late blight.* Bitter rot occurs chiefly in apples, but also attacks quinces, pears, and other plants. It is caused by a fungus that destroys the fruit, twigs, and limbs of the trees. The fungus produces a brown spot in the fruit. The spot grows larger and deeper and may eventually give the fruit a bitter taste.

Black rot attacks cultivated plants, including apples, grapes, pears, quinces, and sweet potatoes. The disease causes dark brown spots in the infected parts. Brown rot destroys peaches and other stone fruits, such as cherries and plums. Small brown spots appear on the fruit and grow until the entire fruit rots. Dry rot affects chiefly timber. Potato late blight produces rot in potatoes. From 1845 to 1847, the potato crop of Ireland failed because of late blight.

Rotary engine is a type of internal-combustion engine that uses a *rotor* (rotating part) instead of a piston. A German engineer, Felix Wankel, developed the first practical rotary engine, called the *Wankel engine,* during the 1950's. It has a triangular rotor design.

A rotary engine differs from a piston engine in several ways. For example, a rotary engine has fewer parts than a piston engine of the same power. A rotary engine also uses lower-octane petrol. However, it burns fuel less efficiently and thus uses more fuel and emits more exhaust pollutants. The noise and vibration produced by a rotary engine tend to be opposite to those of a piston engine. At high speed, a rotary engine operates more quietly and smoothly than a piston engine. But at low speed, a rotary engine makes more noise and vibrates more. When it was introduced, the rotary engine was smaller and weighed less than a piston engine of equal power. But by the early 1980's, manufacturers produced comparably small and lightweight piston engines that were more efficient than rotary engines.

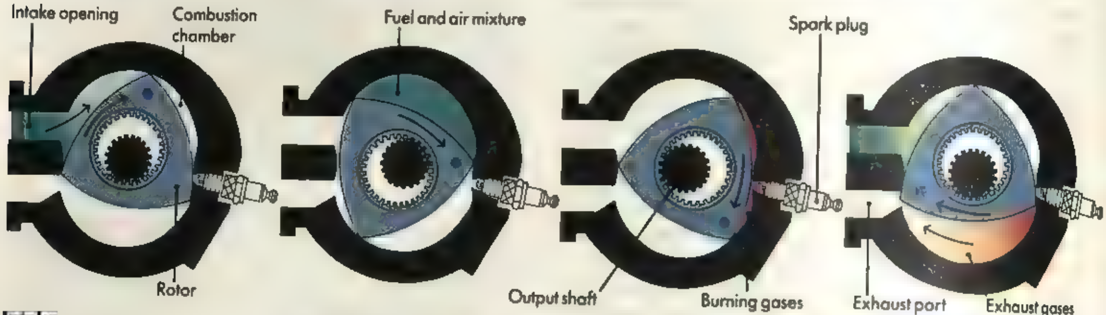
How a rotary engine works. The most important parts of a rotary engine are its triangular rotor and specially shaped chamber. The rotor moves so that its tips always touch the walls of the chamber and divide the

Steel brazed with copper sculpture (1951); Cleveland Museum of Art, Ohio, U.S.A.

Theodore Roszak's *Mandrake* is typical of the fierce, menacing, birdlike forms that appear in many of the sculptor's works.

How a rotary engine works

A rotary engine uses triangular rotors instead of pistons in its specially shaped combustion chambers. As a rotor turns, each of its three sides goes through a four-step cycle that produces power. These steps are (1) intake, (2) compression, (3) expansion or power, and (4) exhaust.



Intake

Fresh air mixed with fuel is drawn into the engine as a tip of the rotor, shown by a dot, passes the intake opening.

Compression

The rotor begins to compress the fuel and air mixture when the following tip of the rotor passes the intake opening.

Expansion or power

The spark plug ignites the mixture. The burning gases expand and move the rotor around the output shaft.

Exhaust

The burned gases leave through the exhaust port after the rotor tip uncovers it. The cycle then begins again.

chamber into three areas. A different part of the combustion process takes place in each of the three areas of the chamber. A rotary engine may have several rotors, each with its own chamber.

A rotary engine, like a piston engine that operates on a four-stroke cycle, goes through four steps to complete one combustion cycle: (1) *intake,* (2) *compression,* (3) *expansion* or *power,* and (4) *exhaust.* During the intake step, a combustible mixture of air and petrol enters the chamber. Then the mixture is compressed. One or two spark plugs then ignite the mixture. The burning produces expanding gases that move the rotor. The exhaust step pushes the burned gases from the engine.

In a piston engine, each piston must move back and forth twice and stop four times to complete the cycle (see **Petrol engine** [diagram: How a four-stroke cycle petrol engine works]). A rotary engine operates continuously. It completes three combustion cycles with each full rotation of its rotor. Each revolution of the rotor produces three power strokes. The output shaft connected to the rotor makes three revolutions each time the rotor turns once. As a result, a single-rotor engine produces one power stroke per turn of its output shaft. A piston engine, on the other hand, produces one power stroke every other time a piston moves down its cylinder. A dual-rotor engine therefore generates the same number of power strokes as a four-cylinder piston engine.

History. Felix Wankel developed the basic principles of the rotary engine during the early 1950's. By 1958, Wankel and researchers at a German engine plant had worked out the engine's design. Car manufacturers rejected the engine at first because of its poor fuel economy, short operating life, and high level of pollution. But after engineers began to solve some of these problems, the rotary engine's simplicity and low cost attracted interest. Several car makers in Japan, Germany, and the United States sought to develop efficient rotary engines. But by the 1980's, the engine's original problems caused many manufacturers to reduce their development efforts.

Rotary International is the worldwide association of all Rotary clubs. A Rotary club is a group of community leaders, each in a different profession or business. The association supervises member clubs and works for the advancement of Rotary. Members provide humanitarian services, encourage high ethical standards, and help build good will and peace in the world.

Rotary International has a cogwheel for an emblem.

The Rotary Foundation of Rotary International sponsors scholarships for study abroad and the exchange of young business and professional people between countries. The foundation also sponsors projects to improve worldwide health. For example, it funds immunization projects in developing countries to protect children against infectious diseases, especially polio.

Paul P. Harris, a lawyer in Chicago, founded Rotary in 1905. It got its name from an early practice of members meeting in rotation at their places of business. There are about 22,000 Rotary clubs in more than 150 countries, with about 1 million members. The official Rotary magazine is called *The Rotarian.* Its Spanish-language edition is *Revista Rotaria.*

Rotary wing aircraft. See Helicopter; Autogiro; V/STOL.

Rotation of crops. See Cropping system.

Rotenone is a poisonous substance taken from the root of the derris and cube plants. It is frequently used in garden sprays because it is poisonous to cold-blooded creatures, but is fairly harmless to warm-blooded animals. Vegetable farmers often use rotenone because this poison kills insects but will not harm the people who may later eat the vegetables.

Rotenone is commonly used in home gardens. It is also used to control animal parasites, including cattle grubs in dairy cattle, and fleas, lice, and ticks. It is used in fruit sprays to control certain pests.

Indians in South America use crushed cube roots to

catch fish. Although the rotenone in the roots kills the fish, the Indians can safely eat them.

See also **Insecticide** (Botanical insecticides).

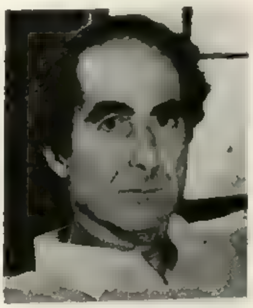
Roth, Mark (1951-), an American, became the all-time leading money winner in professional bowling in 1987. Roth also holds a number of other professional bowling records. He has had the highest average among professional bowlers five times—in 1976, 1977, 1978, 1979, and 1981. His average of 221.662 in 1979 also set a record.

In 1978, he won a record eight Professional Bowlers Association (PBA) titles. Roth has been named PBA Player of the Year four times—in 1977, 1978, 1979, and 1984. He won the U.S. Open and the Touring Players Championship in 1984. Roth was born in Brooklyn, New York He became a member of the PBA in 1970. He was elected to the PBA Hall of Fame in 1987.

Roth, Philip (1933-), is an American novelist and short-story writer. He has received both praise and criticism for his frank, comic, and often satirical portraits of modern Jewish society and family life in the United States.

Roth first gained fame for *Goodbye, Columbus* (1959), a collection of five short stories and a novelette. In the novelette, also called *Goodbye, Columbus,* Roth explored the material attractions and spiritual costs he saw in suburban upper-class Jewish life. Roth's most famous novel is *Portnoy's Complaint* (1969). Some critics have praised the work as a funny, intimate, and accurate study of the guilt feelings of a typical American Jewish son. Other critics have condemned it as a libel on Jewish mothers. *Portnoy's Complaint* also attracted controversy because of its explicit sexual descriptions.

The novels *The Ghost Writer* (1979), *Zuckerman Unbound* (1981), and *The Anatomy Lesson* (1983) describe the artistic struggles and psychological problems of a Jewish-American author. The three novels were reissued in 1985 in a single volume called *Zuckerman Bound.* The book also included an additional short story called *The Prague Orgy.* A fourth Zuckerman novel, *The Counterlife,* was published in 1986. Roth's other novels include *Letting Go* (1962), *The Great American Novel* (1973), *The Professor of Desire* (1977), and *Deception* (1990). He also wrote an autobiography, *The Facts* (1988), and *Patrimony* (1991), an account of his father's battle against a fatal illness. Roth was born in Newark, New Jersey.



Philip Roth

Rothenstein is the name of a family of English painters and art historians.

Sir William Rothenstein (1872-1945) won fame as a portrait painter and was principal of the Royal College of Art, in London, from 1920 to 1935. He was born at Bradford, in West Yorkshire.

Sir John Knewstub Maurice Rothenstein (1901-1992), son of Sir William, was widely known as an art historian. He was director of the Tate Gallery from 1938 to 1964. He was born in London.

Michael Rothenstein (1908-), second son of Sir William, is a painter and printmaker. His works hang in many principal art galleries. He was born in London.

Rother (pop. 80,200) is a local government district in East Sussex. The district has much attractive countryside, and agriculture is the main industry. Tourism is important, and the district has many craft industries, including several potteries. Bexhill-on-Sea is a popular seaside resort, and the towns of Rye and Battle also attract visitors. Battle marks the site of the Battle of Hastings (1066). It has an abbey of Norman origin. See also **Sussex.**

Rotherham (pop. 247,100) is a local government district in South Yorkshire, England, centred on the town of Rotherham. The town has important iron and steel and glass-making industries and a variety of light-manufacturing and engineering industries. Outside the town, coal mining is widespread, and elsewhere mixed farming is important. See also **Yorkshire.**

Rothermere, Viscount. See **Harmsworth** (family).

Rothko, Mark (1903-1970), an American painter, was a leader of the abstract expressionist movement. His best-known paintings are large, boldly simplified abstract compositions. In these works, he relied chiefly on colour and ambiguous boundaries on rectangular forms to create a range of moods. See **Abstract expressionism.**

Rothko was born in Russia. His family settled in Portland, Oregon, in 1913. His real name was Marcus Rothkovitz. Until the early 1940's, Rothko mainly painted recognizable subjects, including city scenes, plants, and animals. Gradually, he began to adapt themes from ancient myths to a poetic semiabstract style. From there he moved into a highly personal reduction of forms to the moody, veil-like surfaces of glimmering colour of his mature style. Shortly before his death, Rothko com-

Oil painting on canvas (1952)

A typical painting by Mark Rothko emphasizes rectangles of colour. Rothko used this type of composition in the above painting, called *Number 8,* and in other large works.

pleted a group of murals for the interdenominational Rothko Chapel in Houston. He worked with dark, low-keyed colours to induce a meditative atmosphere.

Rothschild is the name of a German family that founded a famous banking firm in the late 1700's. The family opened banks in several European countries in the 1800's, and the company became known as the House of Rothschild. The family has also been prominent in industry, philanthropy, politics, and science.

Mayer Amschel Rothschild (1743-1812), who founded the banking dynasty, was the son of a merchant of Frankfurt, Germany. Mayer Rothschild opened a bank in Frankfurt, where he made profitable investments for the royal families of several European nations. He trained his five sons in conservative money management. Rothschild made investments that produced reasonable profits rather than excessive earnings. These methods helped him make a spectacular fortune.

After Rothschild's death, his sons expanded the family business. The oldest son, Amschel Mayer Rothschild (1773-1855), took control of the Frankfurt bank. Branches of the House of Rothschild were opened in Vienna, Austria, by Salomon Mayer Rothschild (1774-1855); in Naples, Italy, by Karl Mayer Rothschild (1788-1855); and in Paris, France, by James Mayer Rothschild (1792-1868).

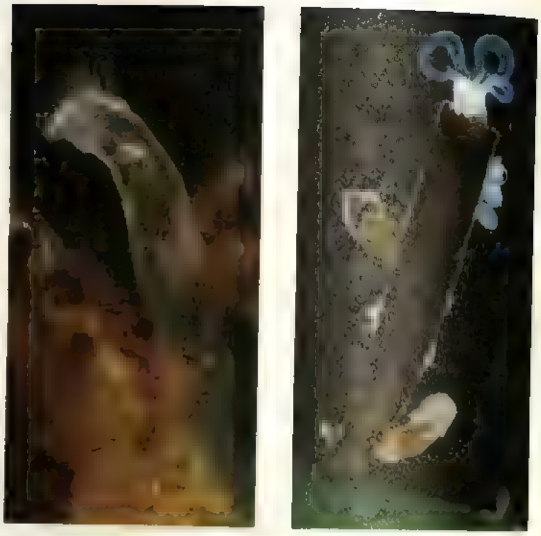
Nathan Mayer Rothschild (1777-1836), the third son of Mayer Rothschild, founded the London branch of the House of Rothschild. He later became a financial agent of the English government. Rothschild helped Great Britain defeat France in the Napoleonic Wars (1796-1815) by providing funds for the British Army.

Lionel Rothschild (1808-1879), Nathan Rothschild's oldest son, won election to the British Parliament six times between 1847 and 1857. But each time he was denied admission because, as a Jew, he refused to take an oath supporting Christianity. Rothschild worked to change the law that required the oath and, in 1858, he became the first Jewish member of the House of Commons. In 1885, his son Nathan Mayer Rothschild (1840-1915) became the first Jew admitted to the House of Lords.

Guy de Rothschild (1909-), the great-great-grandson of Mayer Rothschild, was president of the family's bank in Paris from 1949 to 1981. The French government took control of all privately owned banks in France in 1981. The Rothschild bank in Paris had controlled many of the family's industrial holdings, which the government also nationalized. The Paris branch had been the family's main bank since its bank in Austria closed in 1938, just before World War II. In 1981, Rothschild and his cousin Evelyn de Rothschild, chairman of the London bank, became co-chairmen of the family's American investment company.

Rotifer is a tiny multicellular animal that lives in water. The largest rotifers are about 1 millimetre long. Rotifers have cylinder- or vase-shaped bodies. Most species live in lakes, rivers, or streams. But, some live in the ocean.

The name *rotifer* means *wheel bearer* and refers to the circles of hairlike projections called *cilia* on the animal's head (see **Cilia**). The cilia create a circular water current that draws food to the rotifer. This water current also enables most species of rotifers to "swim." Other species spend their entire lives attached to such objects as stones and leaves.

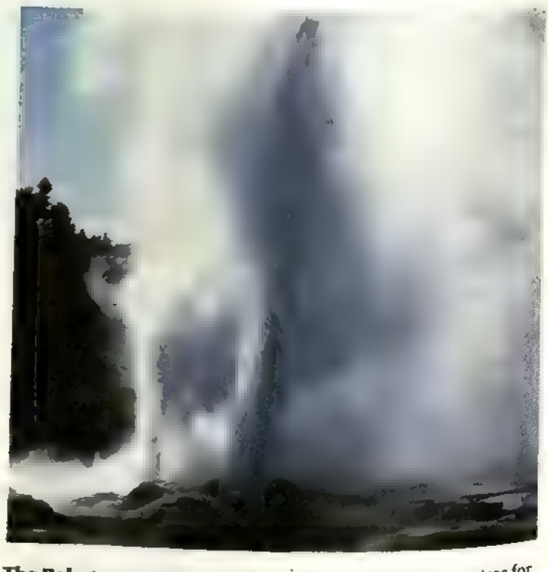


Rotifers are microscopic animals that live in fresh water. The common rotifer, *left,* uses its hairlike cilia to swim. The tube-building rotifer, *right,* can be seen at the top of a brown tube that it has formed from its own body secretions.

In many rotifer populations, the male has no role in reproduction. The female can produce young by herself. This kind of reproduction, called *parthenogenesis,* produces only female offspring.

Scientific classification. Rotifers make up the phylum Rotifera.

Rotorua (pop. 53,702) is a district situated on the volcanic plateau of the North Island of New Zealand. The city area has developed around one side of Lake Rotorua. Rotorua is one of the country's most important tourist centres, offering such attractions as scenic lakes, trout fishing, geothermal activity, Maori arts, and tourist entertainment. It is also a centre of the timber industry.



The Pohutu geyser, in Rotorua, sends water up 30 metres for 30 minutes three times a day.

The Port of Rotterdam in the Netherlands handles more freight than any other port in Europe. Rotterdam's economy depends mainly on its shipping industry, which serves not only the Netherlands but also parts of Germany, France, and Switzerland.

Rotterdam (pop. 558,832; met. area pop. 1,025,580) is the second largest city in the Netherlands. Only Amsterdam is larger. Rotterdam has one of the world's busiest seaports. The city lies on both banks of the Nieuwe Maas River about 31 kilometres east of the North Sea (see **Netherlands** [map]).

In 1872, engineers completed a channel called the Nieuwe Waterweg, which links Rotterdam with the sea. The Nieuwe Maas, a branch of the Rhine River, links Rotterdam with many other cities.

Almost all the buildings in the heart of Rotterdam have been constructed since the end of World War II in 1945. German bombs had destroyed most of the city's central area (see **Netherlands** [picture: Hit by German bombers]). One of the few surviving buildings there, the medieval St. Laurens (or St. Lawrence) Church, is a major landmark of the city. It was badly damaged by the bombing but was repaired after the war. Rotterdam's old harbour district, Delfshaven, escaped destruction. It has several buildings that date from the 1600's.

Most Rotterdammers live in single-family houses or blocks of flats constructed since World War II. Rotterdam has many shopping districts, including the Lijnbaan, a pedestrian shopping mall.

The Boymans-Van Beuningen Museum houses a large collection of Dutch art. A music centre, the Doelen, includes several concert halls. Erasmus University of Rotterdam was founded in 1973.

Rotterdam's economy depends largely on its huge shipping industry. Europoort, the city's vast harbour, serves the Netherlands, the major industrial regions of Germany, and parts of France and Switzerland. Other important industries include oil refining, shipbuilding and repair, insurance, and banking.

Rotterdam became a city in 1328, when it received a municipal charter. It was a small fishing community until the 1600's, when merchants increased their trade with England and France. Rotterdam became a thriving port in the late 1800's after the Nieuwe Waterweg made it possible for large ships to travel between the city and the North Sea.

The German destruction of the city and its port during World War II almost ruined Rotterdam's economy, but the port was quickly rebuilt. In 1957, the Netherlands joined the European Community, an economic association of European nations. Since then, Rotterdam has been a major shipping centre.

See also **Europe** (picture).

Rottnest Island lies off the mouth of the Swan River, about 30 kilometres west of Perth in Australia. It is about 10 kilometres long and 5 kilometres wide. The Dutch navigator William de Vlamingh gave the island its name, which means *rats' nests.* See **De Vlamingh, William.**

Rottnest pine, sometimes called *Swan River pine,* is among the few native Australian pines. This cypress pine can grow to a height of 2 to 4 metres. But most are smaller and straggling in exposed areas where they commonly grow. They have small, scalelike leaves in groups of three, and warty, seedbearing cones. Rottnest pines grow on Rottnest and other islands off the coast of Western Australia.

Scientific classification. The Rottnest pine belongs to the cypress family Cupressaceae. It is *Callitris preissii.*

Rottweiler is a muscular dog with short, coarse black hair. This breed of dog has tan or mahogany markings on the head, chest, and legs. When full-grown, Rottweilers stand from 55 to 70 centimetres high. Most males are larger than the females. Rottweilers were developed in southern Germany, near the village of Rottweil. They are descended from the camp dogs that followed Roman armies in their conquest of southern Europe about 1,900 years ago. The Romans used these dogs to herd the cattle and sheep that provided meat for the armies. The Doberman pinscher developed from the Rottweiler.

Powerful Rottweilers once guarded Roman herds.

Rouault, Georges (1871-1958), was a French artist. He was a deeply religious man with strong moral convictions, and his works show his hatred of hypocrisy, poverty, sin, and war.

Rouault was born in Paris. From 1885 to 1890, he worked for a maker of stained-glass windows. Rouault's paintings, with their hard black outlines and brilliant, intense colour, show the influence of stained-glass designing. About 1905, Rouault was briefly associated with a group of painters called the Fauves (see **Fauves**). The bold brushstrokes and dramatic colour contrasts of the Fauves became important parts of his style. From about 1903 to 1916, he painted religious subjects and sad clowns, and satirical pictures of prostitutes and corrupt judges. These works reflect misery and pain. From 1916 to 1927, Rouault worked on a series of 58 aquatints and etchings. This series, called *Miserere*, was published in 1948 and ranks as one of the greatest achievements in modern printmaking. From 1927 until his death, Rouault painted clowns and religious pictures, but chose fewer satirical subjects.

Oil painting on canvas (1938); Museum of Art, Carnegie Institute, Pittsburgh, Pennsylvania, U.S.A.

Rouault's *The Old King* resembles a stained-glass window with its thick black lines enclosing areas of bright colour.

The rouble is the monetary unit of Russia.

Rouble, also spelled *ruble*, is the monetary unit of Russia and other former Soviet republics. It is divided into 100 *kopecks* (see **Kopeck**). Currency in circulation includes treasury notes (paper money) in values of 1, 3, and 5 roubles. In addition, Russia issues a 100-rouble note. Copper-nickel coins are used in Russia and other former Soviet republics in denominations of 1 rouble and 10, 15, 20, and 50 kopecks. Copper-zinc coins are made in denominations of 1, 2, 3, and 5 kopecks.

Rouen (pop. 105,470; met. area pop. 380,161) is a city in France that is both a major industrial centre and a treasure house of artistic masterpieces. It lies in northern France, on the banks of the Seine River. For location, see **France** (political map).

Rouen's many industries include the production of chemicals, medicines, metals, paper, and textiles; and food processing and petroleum refining. A magnificent Gothic cathedral built between the 1200's and 1500's stands near the centre of Rouen. The city has several other beautiful old churches, art museums that house outstanding collections, and a university. The *Grosse*

The Cathedral of Rouen stands near the centre of the city. It was built from the 1200's to the 1500's and ranks as a masterpiece of French Gothic architecture.

Horloge, a huge clock dating from the 1300's, is another landmark of the city. Rouen serves as the capital of the Seine Maritime *department* (administrative district) and the Haute-Normandie (Upper Normandy) region.

A settlement existed at what is now Rouen in ancient times. In 1431, the English—who controlled Rouen at the time—burned Joan of Arc at the stake in the city. Rouen suffered heavy damage in World War II (1939-1945), but was rebuilt after the war.

Rough Riders is the nickname for a famous American regiment that fought under Theodore Roosevelt's leadership in the Spanish-American War of 1898. The official name of the regiment was the First United States Volunteer Cavalry. About 1,000 men, all "good shots and good riders," were recruited for the unit. It soon became known by the nickname *rough riders,* a popular name for Western cowboys. Leonard Wood commanded the Rough Riders when the regiment was first formed. Later, Roosevelt became colonel in command.

The Rough Riders had their greatest day on July 1, 1898, during the battle of San Juan Hill in Cuba. Roosevelt led his men in a victorious charge up "Kettle Hill," which is near San Juan Hill. Many Americans died in the charge, but those who survived were hailed as heroes. The fame of the Rough Riders later helped Roosevelt in his political activities.

See also **Spanish-American War** (picture).

Roulette is a popular game in gambling casinos. The roulette table consists of a wheel located at one end of the table, and a betting layout extending across the rest of the table surface. Players are seated around three sides of the table. In American roulette, there are 38 symbols around the circumference of the wheel, numbered from 1 to 36 plus a 0 and 00. Many wheels in Europe do not have 00. Each symbol has an identical small slot on the wheel. The numbers are marked on a background alternately of red and black, with the 0 and 00 on a green background.

Players bet by placing chips on the betting layout. Then the dealer, often called the *croupier,* rotates the wheel and at the same time spins a small white ball on the rim of the wheel in the opposite direction to the turning wheel. The ball finally drops into one of the numbered slots. That number and colour become the winner for that spin. Players can bet in many ways. They can bet on single numbers, groups of adjoining numbers, sets of 12 numbers, the red or black colours, odd or even numbers, or the low or high numbers.

Roumania, a variant of Romania. See **Romania.**

Round. See Canon.

Round, Dorothy Edith (1909-1982), was one of Britain's finest tennis players and was famous for her attacking style. She was Wimbledon ladies singles champion in 1934 and 1937. She also won the Wimbledon mixed doubles title in 1934, 1935, and 1936. Her other tennis achievements included wins in the 1933 and 1934 British Hard Court Championships. She was born in Dudley, West Midlands.

Round Table was the table at which King Arthur, the legendary British ruler, sat with his knights. The term *Round Table* also refers to Arthur's entire royal court. The Round Table inspired some of the greatest literature of the Middle Ages. The fullest English account of Arthur and his knights appears in *Le Morte Darthur* (about 1470), a group of *romances* collected and rewritten by Sir Thomas Malory. A romance, in medieval literature, was a long work of fiction that described the remarkable adventures of a hero.

Origin. The first mention of the Round Table occurs in *Le Roman de Brut* (1155), a verse history by the Norman poet Wace. This book tells how Arthur decided to seat his knights around a circular table to avoid quarrels over who should occupy the seats of honour. Since the knights were all "noble and equal," no knight could boast of sitting higher than his peer.

About 1205, the English priest Layamon adapted Wace's book into an English version called *The Brut.* In *The Brut,* bloody fighting broke out among Arthur's knights over the choicest seats at a Christmas feast. To avoid such conflicts, Arthur asked a Welsh carpenter to build a wondrous round table. The table would seat 1,600 men and yet fold up so it could be carried on horseback. According to still another source, Merlin the magician had the table built for Uther, Arthur's father. Uther apparently gave the table to King Leodegan. Later, Leodegan gave the table to Arthur after Arthur married Guenevere, Leodegan's daughter.

Another tradition describes the Round Table as seating 12 and resembling the table at the Last Supper, with an empty place representing Judas' seat. This seat was called the *Siege Perilous,* and was reserved for the knight so pure that he would someday find the Holy Grail, the cup or dish used by Jesus at the Last Supper. Any other knight who sat in the seat would die. One day, Sir Galahad's name appeared on the seat. From then on, he occupied the Siege Perilous. He later was one of three knights who found the Holy Grail.

The knights of the Round Table. In medieval literature, knights considered membership at the Round Table a great honour. Brave men came to Arthur's court from many countries hoping to be chosen a member.

Many romances describe the career of various knights of the Round Table. Several tell of the adventures of Sir Tristram. These stories describe Tristram's skill as a hunter and harp player and his bravery in killing a dragon and a giant. The best-known tale concerns Tristram's love affair with Isolt, the wife of his uncle, King Mark.

Sir Gawain was another famous knight of the Round Table. The great English romance *Sir Gawain and the Green Knight* describes Gawain's bravery and sense of honour as he faces possible death from the gigantic Green Knight. Gawain also shows his moral purity by refusing to be seduced by the Green Knight's beautiful but deceitful wife. Other Round Table heroes included Ban, Bedevere, Ector, Gareth, Kay, Lancelot, Launfal, Palomides, Sagramore, and Ywain.

The decline of the Round Table. For several reasons, the fellowship of the Round Table declined and in time was destroyed. The greatest adventure of the Round Table was the search for the Holy Grail. However, only three knights—Bors, Galahad, and Perceval—were morally perfect and thus able to find the Grail. The fact that so many of Arthur's knights proved themselves morally imperfect damaged the reputation of the Round Table. A scandal also developed over the love affair between Queen Guenevere and Sir Lancelot, perhaps the greatest of the Round Table knights. The scandal de-

stroyed the bonds of respect and friendship that had united all the knights.

The villainous actions of Sir Modred, a knight who was either Arthur's nephew or his son, led to the final destruction of the fellowship of the Round Table. Modred seized Arthur's throne while the king was in France. Arthur quickly returned to Britain after learning of Modred's treachery, and war broke out between the forces of the two men. Arthur killed Modred in battle but received wounds that led to his death. The brotherhood of the Round Table dissolved following the death of Arthur.

Related articles in *World Book* include:

Arthur, King	Holy Grail
Chrétien de Troyes	Lancelot, Sir
Galahad, Sir	Launfal, Sir
Geoffrey of Monmouth	Malory, Sir Thomas

Round towers are a picturesque feature of the landscape in many parts of Ireland. They were built near churches and monasteries between the 900's and 1200's. They were used as belfries for ringing handbells and as places of refuge during raids by Vikings. They vary in height from about 21 to 38 metres and in diameter from 4 to 5·5 metres. About 100 round towers still stand.

By the 1800's, people had forgotten the purpose of round towers. Some writers suggested that the towers had been built as Phoenician fire-temples, astronomical observatories, or tombs. Other even more outlandish explanations were offered. Their true origin was rediscovered in 1833, when George Petrie, an Irish antiquarian, wrote a comprehensive essay on them. See **Petrie, George.**

A round tower at Kilmachduach, in County Galway, *above,* is well preserved. The tower dates from the 1100's.

Roundheads. See Civil War, English.

Roundway Down, Battle of. See Civil War, English.

Roundworm, also called *nematode,* is any of more than 10,000 species of worms. Many species of roundworms live freely in soil, water, dead plants, or dead animals. All other roundworms are *parasites.* They live and feed on living plants and animals, which serve as *hosts.* Some parasitic species cause serious diseases in human beings and other hosts.

A roundworm has a slender body with tapered ends.

Roundworms range in size from microscopic to about 0.9 metre long. They have slender, round bodies with tapered ends. Roundworms have remarkable powers of reproduction and are extremely numerous. For example, researchers have found more than 90,000 roundworms in a single rotting apple.

Nearly all species of roundworms reproduce by laying eggs. Some species produce great quantities of eggs. For example, females of the species *Ascaris lumbricoides* each lay about 200,000 eggs per day for at least 10 months. Among some species of roundworms, the eggs hatch into tiny young that look like the adults. Eggs of other species hatch into young called *larvae,* which gradually transform into adults. Species of roundworms that do not lay eggs give birth to larvae.

Parasitic roundworms may infect a host in a number of ways. Some species enter the host when the host swallows food that contains the roundworm, its eggs, or its larvae. Among other species, the larva burrows into the skin of the host. In other species of roundworms, the larva is taken up by an insect, such as a fly or a mosquito, and transmitted through the bite of that insect to the host.

At least 14 species of roundworms cause infection in human beings. *A. lumbricoides,* which inhabits the small intestine, infects about 65 million people throughout the world. This species of roundworm causes a disease called *ascariasis.* Symptoms of this disease include pneumonia and intestinal pain. The roundworm *Trichuris trichiura* infects the large intestine and occurs in about 350 million people worldwide. It causes *trichuriasis,* a disease characterized by diarrhoea. Other common roundworms that cause disease in humans include *filariae, hookworms, pinworms,* and *trichinae* (see **Filaria; Hookworm; Pinworm; Trichina**).

Scientific classification. Roundworms make up the phylum Nematoda.

See also **Worm** (picture); **Vinegar eel.**

Rous, Francis Peyton (1879-1970), an American medical researcher, proved that viruses cause some types of cancer. In 1910, Rous ground up a cancerous tumour from a chicken and filtered out everything larger than a virus. The resulting liquid produced cancer when injected into other chickens. For many years, scientists scoffed at Rous's discovery. They believed cancer could not be caused by a virus because the disease is not con-

tagious. In 1966, Rous shared the Nobel Prize for physiology or medicine for his work.

Rous was born in Baltimore and studied at Johns Hopkins University. He joined the Rockefeller Institute for Medical Research (now Rockefeller University) in 1909 and worked there for more than 60 years. In 1915 and 1916, during World War I, Rous helped develop a method of storing blood for transfusions. This technique made possible the establishment of blood banks.

Rousseau, Henri (1844-1910), was a French artist who painted some of the most unusual pictures in early modern art. He is called a *primitive* painter because he had no professional training.

The bold colours and decorative patterns of Rousseau's paintings resemble many works by artists called *impressionists* and *nabis*. But unlike such artists, Rousseau portrayed each detail precisely and polished the surfaces of his canvases to a high gloss. Rousseau took many of his subjects—such as a wedding party or a patriotic celebration—from French middle-class life. But he also loved to paint realistic figures and objects in fantastic or mysterious relationships. Rousseau's *The Sleeping Gypsy* is reproduced in the **Painting** article. Such pictures strongly influenced the surrealism movement of the 1920's (see **Surrealism**).

Rousseau was born in Laval. He worked as a minor customs official in Paris until about 1885, when he retired to devote his life to painting.

Rousseau, Jean-Jacques (1712-1778), was a French philosopher. He was the most important writer of the Age of Reason, a period of European history that extended from the late 1600's to the late 1700's. Rousseau's philosophy helped shape the political events that led to the French Revolution. His works have influenced education, literature, and politics.

Early life. Rousseau was born in Geneva, in what is now Switzerland. The Rousseau family was of French Protestant origin and had been living in Geneva for nearly 200 years. Rousseau's mother died immediately after giving birth to him, leaving the infant to be raised by his quarrelsome father. As the result of a fight in 1722, Rousseau's father was forced to flee Geneva. The boy's uncle then took responsibility for his upbringing.

In 1728, Rousseau ran away from Geneva and began a life of wandering, trying and failing at many jobs. He was continually attracted to music. For years, Rousseau was undecided between careers in literature or music.

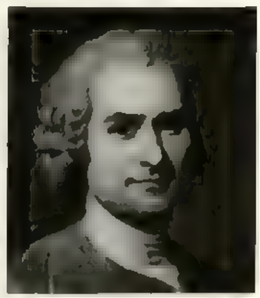
Shortly after leaving Geneva, at the age of 15, Rousseau met Louise de Warens, a well-to-do widow. Under her influence, Rousseau joined the Roman Catholic Church. Although he was 12 or 13 years younger than Madame de Warens, Rousseau settled down with her near Chambéry in the Duchy of Savoy. He described the happiness of their relationship in his famous autobiography, *Confessions* (written 1765 or 1766-1770, published in 1782, 1788). However, the relationship did not last and Rousseau eventually left in 1740.

In 1741 or 1742, Rousseau was in Paris seeking fame and fortune and hoping to establish himself in a musical career. His hope lay in a new system of musical notation that he had invented. He presented the project to the Academy of Sciences, but it aroused little interest.

In Paris, Rousseau became friends with the *philosophes*, a group of famous writers and philosophers of the time. He gained the patronage of well-known financiers. Through their sponsorship, Rousseau served in Venice as secretary to the French ambassador in 1743 and 1744.

The turning point in Rousseau's life came in 1749, when he read about a contest sponsored by the Academy of Dijon. The academy was offering a prize for the best essay on the question: Whether the revival of activity in the sciences and arts was contributing to moral purification. As he read about the contest, Rousseau realized the course his life would take. He would oppose the existing social structure, spending the rest of his life indicating new directions for social development. Rousseau submitted an essay to the academy. His "Discourse on the Sciences and the Arts" (1750 or 1751) attacked the arts and sciences for corrupting humanity. He won the prize and the fame he had so long desired.

Later life. When Rousseau converted to Catholicism, he lost his citizenship in Geneva. To regain his citizenship, he reconverted to Protestantism in 1754. In 1757, he quarrelled with the philosophes because he felt that they were persecuting him.



Pastel portrait on paper (1753) by Maurice Quentin de La Tour; Musee Antoine Lecuyer, Saint-Quentin, France

Jean-Jacques Rousseau

Rousseau's last works are marked by emotional distress and guilt. They reflect his attempt to overcome a deep sense of inadequacy and to find an identity in a world that seemed to have rejected him.

In three *Dialogues,* also called *Rousseau, Judge of Jean-Jacques* (written 1772-1776, published 1782), Rousseau tried to answer charges by his critics and those he believed were persecuting him. His final work was the beautiful and serene *Reveries of the Solitary Stroller* (written 1776-1778, published 1782). Rousseau also wrote poetry and plays in both verse and prose. His musical works include many essays on music, an influential opera called *The Village Soothsayer* (1752), a highly respected *Dictionary of Music* (1767), and a collection of folk songs entitled *The Consolation of My Life's Miseries* (1781). In addition, he wrote on botany, an interest he cherished for many years.

His ideas. Rousseau criticized society in several essays. For example, in "Discourse on the Origin and Foundations of Inequality" (1755), he attacked society and private property as causes of inequality and oppression. *The New Heloise* (1761) is both a romantic novel and a work that strongly criticizes the false codes of morality Rousseau saw in society. In *The Social Contract* (1762), a landmark in the history of political science, Rousseau gave his views concerning government and the rights of citizens. In the novel *Émile* (1762), Rousseau stated that children should be taught with patience and understanding. Rousseau recommended that the teacher appeal to the child's interests, and discouraged strict discipline and tiresome lessons. However, he also felt that children's thoughts and behaviour should be controlled.

Rousseau believed that people are not social beings

by nature. He stated that people, living in a natural condition, isolated and without language, are kind and without motive or impulse to hurt one another. However, once they live together in society, people become evil. Society corrupts individuals by bringing out their inclination toward aggression and selfishness.

Rousseau did not advise people to return to a natural condition. He thought that people could come closest to the advantages of that condition in a simple agricultural society in which desires could be limited, sexual and egotistical drives controlled, and energies directed toward involvement in community life. In his political writings, he outlined the institutions that he believed were necessary to establish a democracy in which all citizens would participate.

Rousseau believed that laws should express the general will of the people. Any kind of government could be considered legitimate, provided that social organization was by common consent. According to Rousseau, all forms of government would eventually tend to decline. The degeneration could be restrained only through the control of moral standards and through the elimination of special interest groups. Robespierre and other leaders of the French Revolution were influenced by Rousseau's ideas on the state. In addition, many socialists and some communists have found inspiration in Rousseau's ideas.

His literary influence. Rousseau foreshadowed *romanticism,* a movement that dominated the arts from the late 1700's to the mid-1800's. In both his writings and his personal life, Rousseau exemplified the spirit of romanticism by valuing feeling more than reason, impulse and spontaneity more than self-discipline. Rousseau introduced true and passionate love to the French novel, popularized descriptions of nature, and created a lyrical and eloquent prose style. His *Confessions* created a fashion for intimate autobiographies.

See also **Age of Reason; Romanticism; Philosophes.**

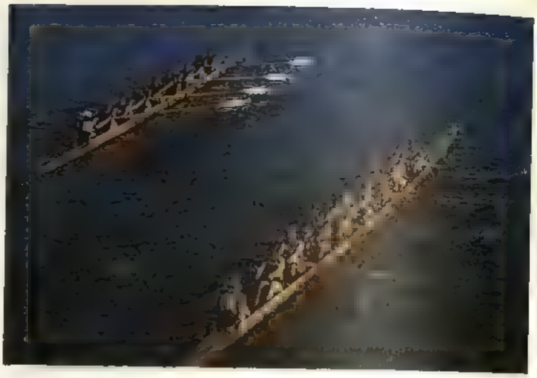
Rowan tree. See **Mountain ash.**

Rowing is the act of propelling a boat with oars. Many people find rowing on lakes and rivers to be a pleasant form of exercise. Rowing races have become important well-organized amateur sporting events.

Boats. Many people learn to row in a wide, heavy boat called a *dinghy.* It is generally *clinker-built* (the hull is built with overlapping planks). The boat is steered by a *rudder* at the *stern* (rear) of the boat. The *oars,* which have round handles and flat blades, turn around in U-shaped *rowlocks* on the sides of the boat. The person rowing sits on a fixed seat.

An oarsman or oarswoman who wishes to compete in races may become a member of the crew of a *four-* or an *eight-*oared boat. Although it is also clinker-built, this boat differs in several respects from a dinghy. It is lighter and much narrower. The rowlocks swivel. The boat is equipped with *outriggers,* often called *riggers,* away from the sides of the boat. The oars are secured in the rowlocks by *gates.* The seats may be sliding. The crew's feet are strapped to foot-rests called *stretchers.* The use of sliding seats and swivel rowlocks makes a longer stroke through the water possible.

The boat is steered by a *cox* (short for *coxswain*), who also shouts orders to the crew. The crew members nearest to the cox is called *stroke.* The one nearest the *bows* (front) of the boat is called *bow.* The stroke sets the pace for the rest of the crew. The other crew members are referred to by a number representing their position in the boat. For example, in a four-oared boat, the crew are called *bow, two, three,* and *stroke.*



Rowing in a race, the rowers respond to the commands of the coxswain, who faces them. The coxswain also steers the shell.

After gaining more experience, a man or woman can move from a clinker to a smooth-skinned boat called a *shell.* The shell is the lightest and fastest of the rowing-boats. An eight-oared shell may be 18 metres long, 60 centimetres wide, and weigh about 130 kilograms.

In another type of rowing called *sculling,* each crew member or *sculler* uses two oars. Both the boat and the oars are called *sculls.* The various sizes of scull craft include *single* sculls for one person; *double* sculls for two people; and *quadruple* sculls for four scullers.

Competition. Rowing is an Olympic sport for men and women. World championships are held in the years between the Olympic Games. The competition is conducted by the International Rowing Federation (FISA), the governing body of rowing.

Rowing races called *regattas* are held annually in many parts of the world. Some of them are open to contestants from all nations.

Rowing in the United Kingdom. Straightforward single races are held in which one crew races against another. This includes the annual Boat Race between Oxford and Cambridge universities. The race takes place in London along the River Thames and lasts for about 20 minutes. It begins at Putney and ends at Mortlake. An internationally famous regatta is the Henley Royal Regatta, held on the Thames at Henley-on-Thames, England.

Rowing in Australia and New Zealand. Rowing is also popular in Australia and New Zealand. The controlling bodies are the Australian Amateur Rowing Council, the New Zealand Amateur Rowing Association, and the Far Eastern Amateur Rowing Association which includes Southeast Asia. The oldest club in Australia is the Melbourne University Boat Club, which was formed in 1858. The Canterbury Rowing Club in New Zealand began in 1861.

The most important race in Australian rowing is the annual Eight Oared Championship, in which crews representing the six states compete for the King's Cup. Championships for the single sculls and lightweight fours are also decided at these regattas. New Zealand held its first national rowing championships in 1887. In

1927, New Zealand held its first Provincial Eights Championships.

History. Rowing-boats with rudders for steering were used before 3000 B.C. The ancient Greeks and Romans travelled in huge rowing-boats called *galleys* (see **Galley**). These boats had long rows of oars, and some had several rows one above the other. The Vikings also were skilled oarsmen. They travelled from Scandinavia as far as North America in their boats (see **Viking**).

The sport of rowing originated in London, where *watermen* (skilled boatmen) rowed ferries across the River Thames. People *wagered* (bet) that one waterman could row across the river faster than another. In 1716, Thomas Doggett, a well-known comedian, established an annual race for watermen. The prize included a colourful coat and a large arm badge. The race for Doggett's Coat and Badge is still held.

The first Oxford and Cambridge Boat Race took place in 1829. Henley Royal Regatta was first held in 1839. The United Kingdom (UK) gradually introduced the sport into other countries. By the 1840's, regattas were being held in several parts of Australia. UK residents of St. Petersburg, Russia, were rowing annually for a sculling trophy on the Neva River. By the 1860's, there were several Russian rowing clubs in St Petersburg, and the sport had spread to other parts of the country.

By the late 1800's, the sport had gained worldwide popularity and was included in the Paris Olympic Games of 1900. The first World Championship regatta was held at Lucerne, Switzerland, in 1962.

Rowland, Daniel (1713-1790), was a founder of Welsh Methodism. He was ordained as a minister in 1733 and was converted to Methodism in 1735. In 1737, he met Howel Harris, with whom he created the Welsh Methodist movement. Rowland broke with Harris in 1750 and emerged as the unchallenged leader of Welsh Methodism. He was born at Pantybeudy, Dyfed, and was curate of Llangeitho.

Rowland, Sir James (1922-), was appointed governor of New South Wales, Australia, in 1981 and retired in 1989. He had served as chief of air staff of the Royal Australian Air Force (RAAF) from 1975 to 1979. James Anthony Rowland was born in Armidale, New South Wales. He studied engineering at Sydney University. He joined the RAAF in 1942 and became a bomber pilot in the Pathfinder Force. He was awarded the Distinguished Flying Cross after a raid on the Ruhr, in Germany, in 1944. In 1945, he was shot down and made a prisoner of war. After the war, he trained as a test pilot. He was awarded the Air Force Cross in 1953 and was knighted in 1977.

Rowlandson, Thomas (1756-1827), was an artist and caricaturist. He was born in London and studied art at the Royal Academy there. He also studied in France and frequently visited other European countries. Rowlandson was a skilled draughtsman and combined this talent with a gift for impish humour. This humour shows in such works as *Vauxhall Gardens* (1784). Many of his caricatures have social or political themes.

Rowntree is the name of a Quaker family of industrialists and social reformers in the United Kingdom.

Joseph Rowntree (1836-1925) established the family cocoa and chocolate business in York. He pioneered industrial welfare and social work. He was born in York.

Benjamin Seebohm Rowntree (1871-1954), the son of Joseph Rowntree, was also born in York. Through his writings, he made an important contribution to the investigation of poverty. His book *Poverty: A Study of Town Life* (1901) was a detailed survey of the incomes and living conditions of the working-class people of York. In a second survey, *Poverty and Progress* (1941), Rowntree showed how the city had benefited from the efforts to improve social conditions. Rowntree was a Liberal and a close supporter of Lloyd George.

Rows. See **Chester.**

Rowse, A. L. (1903-), an English historian, essayist, and poet, has specialized in the Elizabethan period. His most important works include *Sir Richard Grenville of the Revenge* (1937), *Tudor Cornwall* (1941), *The England of Elizabeth* (1950), *The Expansion of Elizabethan England* (1955), *The Elizabethans and America* (1959), *William Shakespeare* (1963), and *Christopher Marlowe* (1964). Alfred Leslie Rowse was born at St. Austell, in Cornwall. From St. Austell Grammar School, he went to Christ Church, Oxford.

Roxas y Acuña, Manuel (1892-1948), served as the first president of the Philippine Republic, after it received its independence from the United States on July 4, 1946. He fought the Japanese in World War II (1939-1945), first as a colonel and then as a guerrilla on the island of Mindanao. The Japanese captured him and forced him to serve as a minor official under the puppet government of Jose P. Laurel. Roxas used his position to shield the spy ring he formed to aid the United States.

Roxas was born in Capiz (now Roxas), on Panay Island. He studied law at the University of the Philippines and became governor of his home province. As speaker of the House of Representatives, he achieved fame as a champion of independence.

See also **Philippines, History of the.**

Roxburgh (pop. 34,615) is a local government district in Borders Region, Scotland. It is known for ruined abbeys at Jedburgh, Kelso, and Melrose. Parts of Roxburgh's southern and eastern boundaries form the border between Scotland and England. Farmers graze sheep and cattle on the hills. Valleys, such as Teviotdale, are suited to arable farming. Roxburgh was formed in 1975 out of the old Scottish county of Roxburghshire. See also **Borders Region.**

Roxby Downs is the site of large mineral deposits, including copper, gold, and uranium. The minerals are located 260 kilometres north of Port Augusta, in South Australia. The area is a dry *gibber plain,* a flat area covered with wind-polished stones. Copper was first discovered there in 1976. In 1979, plans were made to expand exploration and development of the area.

Roy, Raja Ram Mohan (1772-1833), an Indian social and religious reformer, founded the *Brahmo Samaj* (Society of Brahma, or God) in 1828. Members of this Hindu society offered worship as a group with prayers and hymns in a hall without images or pictures.

Ram Mohan Roy was born in Burdwan in Bengal. He worked for the British East India Company and became a revenue officer in 1809. As a young man, he disliked many of the social and religious practices of Hinduism. He studied Islam, Hinduism, Buddhism, and Christianity and knew eight languages, including Arabic, Greek, and Latin. He published books on Hindu philosophy, and

Christianity. In 1811, Roy witnessed his brother's widow being burned alive on her husband's funeral pyre. A widow who died in this way was known as a *sati,* which means a virtuous woman. Three years later, he retired and concentrated on campaigning against the practice of women dying as satis. In 1831, Roy visited the United Kingdom to speak on Indian questions. He died in Bristol.

Roy, Rob. See Rob Roy.

Royal Academy of Arts is an institution in London designed to improve the standards of painting, sculpture, and architecture. It also gives instruction and encouragement to contemporary artists. The Royal Academy was at first assisted by government grants. Today, it is self-supporting. It holds two annual exhibitions, one for the works of masters of the past and one for contemporary artists. Surplus funds are devoted to helping young, impoverished artists

In 1768, the Royal Academy of Arts formed with 40 members, of whom portrait painter Sir Joshua Reynolds was president and Sir William Chambers, secretary. Somerset House was the first home of the Royal Academy. In 1868, schools and exhibition galleries opened in the remodelled Burlington House in Piccadilly.

Royal Academy of Dramatic Art. See Theatre (Training for the theatre).

Royal Air Force. See Air force (World War II); **World War II** (The Battle of Britain).

Royal Australian Mint, in Canberra, Australia, makes the coins used in Australia. It is an agency of the Department of the Treasury. Before this large establishment opened in 1965, branches of the Royal Mint operated in Melbourne and Perth. The branch in Melbourne is now closed and the Perth branch is now an agency of the government of Western Australia. The Royal Australian Mint has no connection with the Royal Mint in London.

Royal Automobile Club (RAC) is one of the two main clubs for motorists in Britain. The other is the Automobile Association (AA). The RAC runs a service of patrols to assist its member motorists, and provides a breakdown service, touring information, and legal and other services. The RAC was founded in 1897 as the Automobile Club of Great Britain and Ireland. It received its present name in 1907.

Royal Canadian Mounted Police (RCMP) is the national law enforcement department of Canada. The fame of the Mounted Police has spread throughout the world since the force was organized in 1873. Today, the Mounted Police travel in motor vehicles instead of on horses. But the men on horseback still live in the many books and films about them. The badge of the Royal Canadian Mounted Police bears the organization's motto, *Maintiens le droit* (Maintain the right).

Organization and duties. The Royal Canadian Mounted Police enforces federal law throughout Canada. It is the only police force in the Northwest Territories and the Yukon Territory. Members of the RCMP serve as provincial police in all provinces except Ontario and Quebec, which have their own police forces. The RCMP also provides police protection in some municipalities.

The Royal Canadian Mounted Police maintains over 4,500 land motor vehicles, including cars, trucks, and snowmobiles. It has police dogs and horses, but the horses are used only for ceremonies. The force also has air and marine services. The air services maintain aircraft at strategic points throughout Canada. The marine services operate about 15 patrol vessels and over 300 small boats on Canada's two coasts, the St. Lawrence River, and the Great Lakes.

The solicitor general of Canada oversees the force. A commissioner directs its activities from headquarters in Ottawa. The RCMP has 13 police divisions with headquarters in the provincial capitals. Three other divisions deal with administration and training.

Uniform. The working uniform of male members of the Mounted Police includes a cloth cap, brown *tunic* (jacket), brown leather gloves, dark blue trousers with broad yellow stripes, and small arms equipment. The women's uniform is similar, but female members may wear dark blue skirts when weapons are not required.

The Royal Australian Mint, in Canberra, produces all of Australia's coins. It was established to strike the new decimal coins. Decimal currency was introduced in 1966.

The Royal Canadian Mounted Police wear a scarlet uniform. The colour was chosen because Indians of Canada's western plains considered scarlet a symbol of justice and fair dealing.

The Royal Easter Show is held in Sydney each year. The Grand Parade of animals in the main ring of the showground, *left*, is one of the highlights of the show.

At ceremonies, the Mounted Police still wear their famed uniforms with wide-brimmed hats and scarlet dress tunics. The dress uniform for women includes a cloth cap, scarlet tunic, and dark blue skirt.

History. In 1870, Canada's Dominion government acquired the vast, thinly populated territory of the Canadian Northwest. Disputes broke out there between Indians and whisky traders, and criminal bands began to cause trouble. Government officials feared that war would develop between the Indians and white settlers after settlers began to arrive in the Northwest. The government decided that the area must be controlled. On May 23, 1873, the Canadian Parliament created a mounted police force to prevent bloodshed and to preserve order in the region. This force soon became known as the North-West Mounted Police.

The first members of the force were trained during the winter of 1873-1874. The following summer, about 300 riders headed west across the plains between Manitoba and the Rocky Mountains. They established posts there and quickly halted the smuggling of whisky across the border. In cooperation with the Blackfoot chief Crowfoot and other Indian leaders, the N.W.M.P. soon brought law and order to the plains.

King Edward VII officially recognized the North-West Mounted Police in 1904 when he granted it the prefix *Royal.* The force became the Royal Canadian Mounted Police in 1920 when it merged with the Dominion Police and took over federal law enforcement.

Royal Commission is a body appointed by the British Crown to carry out an inquiry. Its *terms of reference* define its objects. It is composed of a small number of people who are unpaid. Their inquiries may be made into the operation of laws, alleged grievances, conditions within an industry, or social or educational matters. Its findings are presented in a report to the home secretary. A royal commission cannot compel the production of documents or the giving of evidence unless it is expressly given these powers by Act of Parliament. In Australia and New Zealand, governments ask the governor general or state governor to appoint someone to hold a royal commission and make a report.

Royal Dutch/Shell Group is one of the world's major industrial enterprises. It consists of more than 900 firms, which operate in over 100 countries. Its parent companies are the Royal Dutch Petroleum Company of the Netherlands and the "Shell" Transport and Trading Company, P.L.C., of Great Britain.

The Royal Dutch/Shell Group's major activities involve all operations of the petroleum industry—exploration, production, transportation, refining, marketing, sales, and research. The companies also have interests in the chemical, coal, metal, natural gas, and nuclear energy industries. The group grew out of an alliance made in 1907 by the parent companies. For information about the group's sales, assets, and number of employees, see **Manufacturing** (table: 25 leading manufacturers outside the U.S.).

Royal Easter Show, organized by the Royal Agricultural Society of New South Wales, Australia, is an exhibition of agricultural, pastoral, dairying, industrial, and commercial production. The showground occupies 28.75 hectares at Moore Park, in Sydney. Competitive shows of cattle, goats, horses, pigs, dogs, cats, poultry, flowers, vegetables, and arts and crafts attract many entries.

More than 14,000 animals are exhibited each year. Nearly 200 judges take charge of the various sections. More than a million people visit the show each year. The industrial exhibits display goods from 600 exhibitors, and the wine prizes are reputed to be Australia's highest award for wines.

Royal Exchange is a building in the City of London. It consists mainly of the offices of the Royal Exchange Assurance Company. Exhibitions and part of the Guildhall Museum are in its courtyard. In 1537, Sir Richard Gresham proposed the building of an exchange as a fashionable bazaar and gathering place for merchants. His son, Sir Thomas Gresham, began to build the exchange in 1566 (see **Gresham, Sir Thomas**).

Queen Elizabeth I gave the exchange the title *Royal* in 1571. The Royal Exchange burned down in the Great Fire of 1666, and again in 1838. The present building dates from 1844. It was designed by Sir William Tite.

The royal family of Japan. Emperor Akihito and Empress Michiko at the ceremony of the declaration of the succession of Prince Naruhito.

Royal families

Royal families are the families of reigning monarchs—kings, queens, emperors, empresses, sultans, emirs, or other sovereigns. A royal family consists of the monarch of a particular nation state and the monarch's immediate relatives—spouse, children, grandchildren, brothers and sisters, and parents.

A royal family is not necessarily the same as a *ruling family* (one which controls the government). In many countries—the United Kingdom for example—the monarch is a head of state but takes no part in government. Some ruling families who do control the government of a country are not royal. For example, the ruling family of Kuwait is not royal. This type of family is usually not descended from an ancient noble ancestor.

In prehistoric times, the leaders of tiny communities were probably *elected* (chosen by the people). Eventually, such leaderships became *hereditary* (passed on within one family from one generation to the next). In recorded history, one of the earliest *dynasties* (series of rulers from the same family), was that of the pharaohs of Egypt. According to tradition, there were 30 successive dynasties of pharaohs up to the time of Alexander the Great, who invaded Egypt in the 300's B.C.

Royal families today

Types of royal family. Royal families are defined by the status of the monarch who may be either a constitutional monarch, a divine monarch, or an absolute monarch.

Most royal families of the world belong to *constitutional monarchies.* These royal families cannot run the government and have limited political authority. Instead, they have powers and duties defined by constitutional agreement. Belgium, Liechtenstein, Malaysia, the Netherlands, and the United Kingdom have constitutional monarchies.

Divine monarchs and often their immediate family are considered to be representatives of their people's god or gods in human form. Their leadership is both spiritual and political. This form of government is rare today. Western Samoa is still a divine monarchy.

Absolute monarchs govern as the principal executive, legislative, and judicial authority in a country. Their word is law and they may have power of life and death over their subjects. Brunei, Oman, and Saudi Arabia are examples of an absolute monarchy.

Role of royal families. Royal families serve certain needs within a society or culture. The monarch and other members of the royal family *symbolize* (stand for) a nation and all its finest qualities. They represent the religious, historical, and cultural identity of a group of people. Many of those who support the existence of royal families believe that they have a duty to strengthen and preserve morality and tradition. The way a country's royal family lives should set a good example for its people.

Nearly every country in the world has had a royal family at some point in its history. However, political and social changes have often altered the way in which a nation's people regard their royal family. In many cases, the people of a country have *deposed* (removed from office) or even executed their monarch, and then formed a republic (see **Republic**). There are several republics today whose royal families live in exile.

This article describes a few of the royal families of the world. The table with this article lists a number of countries, together with their reigning house or dynasty and their reigning monarch.

Royal families around the world

Europe. Some of the monarchs of European countries belong to families that date from medieval times. Other European royal families have more recent origins. Through intermarriage or because of political events, several *royals* (people of noble royal blood) are members of more than one family. For example, Prince Philip, Duke of Edinburgh, is the husband of Queen Elizabeth II of the United Kingdom. He also belongs to a branch of the Danish royal family whose members were nominated by the United Kingdom to become sovereigns of Greece in the 1800's.

Many countries became republics during the 1900's. In 1917, Russia underwent a violent Communist revolution, and the Russian *czar* (monarch) and members of his family, the Romanovs, were murdered. King Constantine II of Greece and King Michael of Romania are monarchs who now live in exile.

Belgium. Leopold of Saxe-Coburg-Gotha became the first king of the Belgians in 1831, shortly after Belgium won its independence from the Netherlands. The monarchy has remained in place to the present. In 1993, on the death of his brother King Baudouin, Albert II (1934-) succeeded to the throne. The king and his wife Queen Paola (1937-), who is a member of the Italian princely family of Ruffo di Calabria, have three children. They are Prince Philippe (1960-), Princess Astrid (1962-), and Prince Laurent (1963-).

Belgium is a constitutional monarchy. The person of the king is *inviolable* (may not be harmed).

Denmark. The Danish royal family dates from the reign of King Gorm in the 900's. In 1848, King Frederik VII accepted a constitution for Denmark and created a Parliament. The present monarch, Queen Margrethe (1940-), assumed the throne upon the death of her father, King Frederik IX, in 1972.

The Danish royal family is headed by the monarch, Queen Margrethe Alexandrine Torhildur Ingrid, and her husband, the former Count Henri de Laborde de Monpezat, now Prince Henrik. The couple married in 1967. They have two sons, Crown Prince Frederik André Henrik Christian (1968-), and Prince Joachim (1969-).

Monaco. The royal house of Grimaldi rules Monaco. Monaco is a *principality* (ruled by a prince.) In 1308, Francis Grimaldi of Genoa, Italy, was granted governing rights over Monaco by the Genoese, who controlled it at that time.

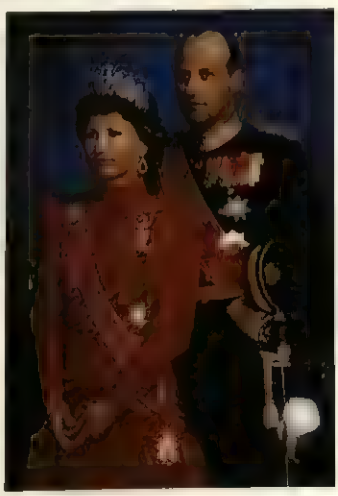
The present royal family consists of Prince Rainier III (1923-), and the three children of his marriage to the U.S. film star Grace Patricia Kelly (1929-1982), who took the title Princess Grace. The children are Princess Caroline Louise Marguerite (1957-), Prince Albert Alexandre Louis Pierre (1958-), and Princess Stéphanie Marie Elisabeth (1965-). There are three children born of the marriage of Princess Caroline to Stefano Casiraghi. They are Andrea (1984-), Charlotte (1986-), and Pierre (1987-). Monaco has a constitutional democracy. Under the terms of a treaty signed with France in 1918, if the Royal Family of Monaco produces no male heirs, the principality will come under French rule.

Netherlands. The royal house of the Netherlands is the House of Orange-Nassau. Prince William I of Orange (reigned 1572-1584), also known as William the Silent, is generally regarded as the founder of the Dutch State (see **William I, Prince of Orange**). The Netherlands changed from a republic to a monarchy in 1813, under King William I. The present monarch, Queen Beatrix, came to the throne in 1980 on the abdication of her mother Queen Juliana (1909-). Her father is Prince Bernhart (1911-).

Queen Beatrix Wilhelmina Armgard (1938-), is married to George Willem Otto Frederik Geert, Prince of the Netherlands. They have three sons, the Prince of Orange, Willem Alexander Claus George Ferdinand (1967-), Prince Johan Friso Bernhard Christiaan David (1968-), and Prince Constantijn Christof Frederik Aschwin (1969-). The Queen has a sister, Princess Margriet Francisca, who is married to Pieter van Vollenhoven. They have four sons. The Netherlands has a constitutional monarchy.

King Carl XVI Gustav of Sweden and Queen Silvia.

King Juan Carlos of Spain and Queen Sofia.



King Harald of Norway and Queen Sonja.

Norway. The present Norwegian monarchy began with the nation's independence from Sweden in 1905. In that year, the Norwegian parliament, the Storting, approved Prince Carl of Denmark as their king. He took the name Haakon VII. The present monarch, King Harald (1937-   ), was the first Norwegian prince born on Norwegian soil for 567 years. He is the son of King Olav V (1903-1991) and Crown Princess Martha (1901-1954).

King Harald married Sonja Haraldsen (1937-   ), a commoner, in 1968. She took the title Crown Princess Sonja. They have two children, Crown Prince Haakon (1973-   ), and Princess Martha Louise (1971-   ).

Spain. The line of royal descent of the present Spanish Royal Family involves the houses of Aragon and Castille and the royal lines of Habsburg and Bourbon. King Juan Carlos Victor Maria de Borbon y Borbon (1938-   ) began to reign in 1975 after the death of the dictator General Francisco Franco.

The Spanish Royal Family is headed by King Juan Carlos and Queen Sofia (1938-   ), the daughter of King Paul and Queen Fredericka of Greece. They were married in 1962. They have three children: the Infanta Doña Elena (1963-   ), the Infanta Doña Cristina (1964-   ), and the Crown Prince Don Felipe (1968-   ). Spain has a parliamentary monarchy.

Sweden. The present Swedish Royal Family is descended from Jean Baptiste Bernadotte (1763-1844), a French officer who ruled Sweden as regent under Napoleon. In 1818, he was elected by the ruling parliament, the Riksdag, as King Charles XIV (Carl XIV Johan).

The Royal Family is headed by King Carl XVI Gustaf (1946-   ), who came to the throne in 1973. He has four older sisters: Margaretha, Birgitta, Désirée, and Christina. In 1976, he married Silvia Sommerlath (1943-   ), a hostess and interpreter. They have three children: Crown Princess Victoria (1977-   ), Prince Carl Philip (1979-   ), and Princess Madeleine (1982-   ). As a constitutional monarch, the king has principally symbolic duties.

United Kingdom. The Royal Family of the United Kingdom is headed by Queen Elizabeth II of the Royal House of Windsor. For further information, see **Royal Family of the United Kingdom.**

Asia. China and India have been republics for many years. In China, the Manchu dynasty, the last royal family to rule, was overthrown in 1912. Before India became part of the British Empire in the 1800's, it was divided into princely states ruled by *maharajahs* (Hindu royal princes). The title *maharajah* means "great king." Many of the maharajahs had great wealth. Under British rule, the maharajahs became administrators. With the independence and partition of India in 1947, the former princely states gradually became part of a unified republic. In 1971, the Indian government amended the Constitution and stripped the maharajahs of their enormous wealth and power. See **India, History of.**

In the Middle East, nations such as Saudi Arabia were founded in the 1900's, but their ruling families are descended from ancient Arab dynasties and reign as absolute monarchs.

Brunei. The royal lineage of the Islamic sultans of Brunei is said to begin with Sultan Awang Alak Bekatar in the 1400's. The current sultan, Sir Muda Hassanal Bolkiah (1946-   ), succeeded to the sultanate in 1967.

The sultan of Brunei, Sir Muda Hassanal Bolkiah, in a procession to mark his twenty-fifth anniversary as sultan.

He has two wives—Princess Raja Isteri, by whom he has six children, and Princess Mariam, by whom he has three. The sultan has two brothers, one of whom, Prince Jefri, is the present minister of finance.

In Brunei, the royal will is absolute. The sultan is both prime minister and minister of defence. He is reputed to be the third richest man in the world.

Cambodia. King Norodom Sihanouk returned to the throne on Sept. 24, 1993, after an absence of 24 years. Following the death of his father, King Norodom Suramarit, in 1960, Sihanouk was elected head of state. He abolished the monarchy and remained as Cambodia's political leader until 1970.

Japan. The Japanese monarchy, symbolized by the Chrysanthemum Throne, is said to be the oldest in the world. Its beginning is shrouded in myth and dates back to the 600's B.C. and the reign of Jimmu Tenno, considered to be the descendant of the Sun Goddess. The present emperor, Akihito, is believed to be the 125th sovereign of this line.

Akihito's father, Emperor Hirohito, succeeded to the throne in 1926 (see **Hirohito**). His reign witnessed Japan's transition from a divine to a constitutional monarchy in 1947 after Japan was defeated in World War II. He and his wife had seven children, including the present emperor, Akihito I. In 1959, Akihito became the first member of the Japanese royal house to marry a commoner, Shoda Michiko (1934-   ), the daughter of a businessman. The royal couple have three children, Crown Prince Naruhito (1960-   ), Prince Fumihito (1965-   ), and Princess Sayako (1969-   ). Prince Naruhito married Masako Owada, a member of the diplomatic corps, in June 1993.

Jordan. The present monarch of the modern kingdom of Jordan, King Hussein bin Talal (1935-   ), belongs to the family that ruled the Hashemite kingdom of Mecca, or Makkah, now in Saudi Arabia, from 1201 until 1925. King Hussein is the 42nd direct descendant of the prophet Muhammad through the male line of the prophet's grandson Al-Hassan.

King Hussein succeeded to the throne in 1952. He married American-born Queen Noor Al-Hussein in 1978. The couple have four children, Prince Hamzah (1980-   ), Prince Hashem (1981-   ), Princess Iman

(1983-), and Princess Raiyah (1986-). King Hussein has seven children from three previous marriages and an adopted daughter, Abir Muhaisin. The king has two brothers and a sister—Prince Mohammad, Crown Prince El Hassan, and Princess Basma.

Under its 1946 constitution, Jordan is a hereditary, constitutional monarchy with a parliamentary system. The throne is passed on by inheritance through the male line. The king designates the heir to the throne.

Malaysia. Malaysia has a unique form of rotating, elective monarchy established in 1957 as a way of sharing power among the nine hereditary rulers of the country. Each ruler, or *yang di-pertuan agong,* rules for a period of five years.

The yang di-pertuan agong is a constitutional monarch whose powers are limited by democratic *consensus* (agreement). Tuanku Jaafar Al-Marhum Tuanku Abdul Rahman was named yang di-pertuan agong in 1994. He is the ruler of the state of Negeri Sembilan. Tuanku Jafaar became the tenth successive monarch of Malaysia, succeeding Sultan Azlan Shah, who ruled from 1989 to 1994.

The royal family is headed by Tuanku Jaafar (1922-) and his wife Tunku Ampuan Najiha. They have three sons, Tunku Naquiyuddin, Tunku Imran, and Tunku Nadzaruddin, and three daughters, Tunku Dara Naquiah, Tunku Jawahir, and Tunku Irinah.

Nepal. The present Nepalese royal family traces its descent back to Gurkha invaders, led by King Prithwi Narayan Shah, who conquered Nepal in 1766. Between 1846 and 1951, the family of Jung Bahadur, the so-called Rana of Nepal, held the political leadership of the country. In 1950, the exiled King Tribhuwan Bir Bikram Shah (1906-1955) led a revolt against the Rana politicians. A constitutional monarchy was formed with multi-party elections. King Tribhuwan's successor, King Mahendra (reigned 1955-1972), reimposed an absolute monarchy in 1960. The present monarch is King Birendra (1945-), grandson of King Tribhuwan. He succeeded to the throne in 1972. He and his wife Queen Aishwarya (1949-) have three children, the Crown Prince Dipendra, Princess Shruti Rajya Laxmi, and Prince Nirajan.

King Bhumibol Adulyadej of Thailand.

King Fahd ibn Abd al-Aziz of Saudi Arabia.

In 1990, a national uprising forced King Birendra to create a modern constitutional monarchy. He has few interests beyond his duties as king.

Oman. The royal lineage of Oman is traced from the Azd and Yarubi tribes who settled in the region soon after 100 B.C. An ancestor of the present sultan, Al Bin Said, freed the nation from Persian control in the 1700's and established the Al Bin Said dynasty. In 1932, the present sultan's father, Sultan Sajid Said, was crowned. Sultan Sajid Said abdicated in favour of his only child, Qaboos (1940-), in 1970.

The Omani Royal Family consists of Sultan Qaboos and his two wives, one of whom belongs to a Bedouin tribe. There is no immediate heir apparent to the throne. Sultan Qaboos is an absolute monarch.

Saudi Arabia. The royal line of the Saud dynasty, to which the Saudi royal family belongs, began in the mid-1400's, when the family ruled from the area of the present city of Riyadh. Ottoman Turks forced the Saud family into exile in Kuwait during the 1800's. The Saud family regained control of Arabia in the early 1900's, and in 1932 King Abd al-Aziz ibn Abdulrahman ibn Faisal al-Saud (1880-1953) united the Kingdom of Saudi Arabia. The present monarch, King Fahd ibn Abd al-Aziz (1923-), succeeded in 1982, following the death of his brother and two half-brothers.

The Saudi royal family also includes the king's brothers, Crown Prince Abdullah ibn Abd al-Aziz Saud (1924-), deputy premier and head of the National Guard, and Prince Sultan ibn Abd al-Aziz (1928-), the second deputy premier, minister of defence and aviation, and inspector general. There are hundreds of members of the extended family of the Saudi royal house occupying various prominent positions in the state. In Saudi Arabia, the king rules as absolute monarch.

Thailand. Thailand has been ruled by the Chakri dynasty since 1782. The present king, Bhumibol Adulyadej (Rama IX) (1927-), is the 9th king of this dynasty. The kings of Thailand ruled as absolute monarchs until 1932, when King Prajadhipok (Rama VII) established a constitutional monarchy.

The Thai Royal Family is headed by King Bhumibol and Queen Sirikit (1932-). The royal couple married

in 1950 and have four children: Princess Ubol Ratana (1951-), Prince Vajiralongkorn (1952-), Princess Sirindhorn (1955-), and Princess Chulabhorn (1957-). The Crown Prince Maha Vajiralongkorn is married to Princess Soamsawali, and has a daughter, Princess Bajrakitiyabha. Princess Chulabhorn, is married with two daughters.

Africa. Most countries in sub-Saharan Africa won independence from colonial rule in the mid-1900's. The majority of them have presidential governments, but a few states continue to have monarchs. One country, Uganda, has four, each ruling one of the ethnic groups making up Uganda's population. One of these, King Ronald Muwenda Mutebi II, the 36th kabaka of the Bugandan nation in Uganda, was crowned in 1993 after spending nearly three decades in exile in England. In South Africa, King Goodwill Zwelethini is the traditional leader of the Zulu nation. Lesotho has a young king in the person of King Letsie III, a descendant of King Moshoeshoe, the founder of the Sotho nation.

Among Islamic countries, Egypt drove out its royal family in 1952. Fuad II, the son and heir of King Faruk, was never allowed to rule after his father was forced to *abdicate* (renounce his throne) by army officers. The former royal family of Libya, also driven out by a military coup, is represented by Crown Prince Al-Mahdi al-Hassan al-Sanusi (1962-). The crown prince lives in exile in Jordan.

Morocco. The institution of an Islamic Moroccan monarchy began with the Idrisid dynasty in the 700's. The present Moroccan royal family dates from the mid-1500's when the Arab Sharif tribe formed a ruling dynasty. The present royal family is descended from the Alawi family, a group within the Sharif tribe. King Moulay Hassan II (1929-), the son of King Muhammad V (1909-1961), is the 17th sovereign of the Alawite dynasty.

The present Moroccan Royal Family also includes King Hassan's son Crown Prince Sidi Muhammad (1963-). The king has four other children, Princess Lalla Meriem (1962-), Princess Lalla Asma (1965-), Princess Lalla Hasna (1967-), and Prince Moulay Rachid (1970-). Morocco became a constitutional monarchy in 1962.

Swaziland. The royal line of the Swazi kings can be traced from the 1600's. The present king, Mswati III (1968-), is the son of King Sobhuza II (1899-1982). He is the world's youngest monarch. The king has six wives and four children. His mother, Queen Indlovukazi Ntfombi, is held in high regard and lives in the principal royal residence which is outside the capital Mbabane.

Related articles in *World Book.* See the separate biographies of some monarchs and their countries' articles. Other articles include:

Czar	Queen
Emperor	Rajah
Kaiser	Shah
King	Sultan

Some royal families of the world

Country	Type of monarchy	Dynasty	Date founded	Reigning monarch*
Belgium	Constitutional	Saxe-Coburg-Gotha	1831	Albert II
Bhutan	Semi-divine	Wangchuk	1907	Jigme Singye Wangchuk
Brunei	Absolute	Bolkiah	—	Sultan Sir Muda Hassanal Bolkiah
Denmark	Constitutional	—	A.D. 900's	Queen Margrethe
Japan	Constitutional	—	A.D. 600's	Emperor Akihito
Jordan	Constitutional	—	1946	Hussein bin Talal
Liechtenstein	Constitutional	Liechtenstein	1806	Prince Hans-Adam
Luxembourg	Constitutional	Nassau	1890	Grand Duke Jean
Malaysia	Constitutional	Negeri†	—	Tuanku Jaafar
Monaco	Constitutional	Grimaldi	1297	Prince Rainier III
Morocco	Constitutional	Alawi	1600's	Hassan II
Nepal	Constitutional	—	1766	Birendra
Netherlands	Constitutional	Orange	1544	Queen Beatrix
Norway	Constitutional	—	1905	Harald
Oman	Absolute	Al Bin Said	1700's	Sultan Qaboos
Saudi Arabia	Absolute	Saud	1400's	Fahd ibn Abd al-Aziz
Spain	Constitutional	Bourbon	1701	Juan Carlos
Swaziland	Constitutional	—	—	Mswati III
Sweden	Constitutional	Bernadotte	1818	Carl XVI Gustaf
Thailand	Constitutional	Chakri	1782	Bhumibol
Tonga	Constitutional	Taufa'ahau	1845	Toupou IV
United Kingdom	Constitutional	Windsor	1917	Queen Elizabeth II
Western Samoa	Divine	—	—	Malietoa Tanumafili II

*Unless otherwise stated, the reigning monarch in each case is a king.
†One of nine dynasties that share the monarchy in rotation. The ruling family changes every five years.

King Ronald Muwenda Mutebi II, of the Ugandan kingdom of Buganda, was crowned in 1993.

Members of the Royal Family appear on the balcony of Buckingham Palace after the ceremony of trooping the colour, which takes place on the queen's official birthday.

Royal Family of the United Kingdom

Royal Family of the United Kingdom is the family of the reigning monarch of Great Britain and Northern Ireland. Queen Elizabeth II, who has been the monarch since 1952, is currently the most important member of the Royal Family. Around her is the inner circle of her immediate relatives. The senior member of this circle is her mother, the former Queen Elizabeth, who is the widow of King George VI. She is now the *Queen Mother.* The other chief members are the queen's husband Prince Philip, Duke of Edinburgh, and their four children Charles, Prince of Wales, the Princess Royal (Princess Anne), Prince Andrew, and Prince Edward.

In addition, there is a wider circle consisting of Queen Elizabeth II's sister Princess Margaret and other descendants of their grandfather, King George V. Members of this more extended family also occasionally represent the queen at public occasions, and people sometimes speak of them collectively as "the Royals."

The queen and her family are traditionally regarded with great affection and respect. Like those who came before her in the Windsor *dynasty* (line of monarchs), she is a symbol of the power and prestige of the United Kingdom. She is also the head of the Church of England and the Commonwealth of Nations. Her portrait is on all United Kingdom postage stamps. Her coat of arms, or sometimes the simple image of a crown, appears on every official document and building. People often use the term *the Crown* to mean the monarchy as an institution and symbol of the nation (see **Crown, The**).

Tradition also demands that, since the Royal Family represents so many things, it should itself be above reproach. Since the time of the present queen's great-great-grandmother Queen Victoria (reigned 1837-1901), it has been assumed that the monarch's family life must be a moral and religious example to others. Although Queen Elizabeth's own life has strictly observed these standards, a number of incidents concerning her children have shaken this view. In the early 1990's, while respect and affection for the queen remained high, the reputation of the Royal Family as a whole declined. See the *History* section of this article.

At work

The queen and Parliament. The United Kingdom is a *constitutional monarchy.* It is a country with an unwritten *constitution* (set of laws) in which the monarch, or sovereign, is head of state, although not of the government. As the monarch, Queen Elizabeth's most important official duty is the State Opening of Parliament. This ceremony is performed annually or after a general election. Accompanied by other members of the family, the queen travels by ceremonial horse-drawn coach from Buckingham Palace, her London home, to the House of Commons (the lower house of Parliament). She reads a speech prepared for her by the prime minister outlining the legislation proposed for the new session of Parliament (see **Parliament**). The purpose of the ceremony is to enhance the dignity and authority of Parliament, which now wields the supreme power that once belonged to the queen's predecessors. However, although Parliament alone has the right to introduce and discuss legislation, Acts of Parliament can only become law after the queen has signed them. This process is called the *Royal Assent.*

In addition, the queen still has a set of powers known collectively as the *Royal Prerogative.* The most important is the right to appoint the prime minister. The generally agreed *convention* (custom) is that the queen invites the

leader of whichever political party has a majority in the House of Commons to take the post. If no party had a majority, or the majority party had no recognized leader, it would remain the queen's duty to appoint a premier and a government, or to call for new elections. She also has the right to pass Orders in Council through her *Privy Council* (private group of advisers) composed of officials and politicians from all parties.

Once a government is installed, the queen remains in close contact with it. The prime minister visits her each week and has a meeting with her called an *audience* to report on parliamentary business. In addition, she sees all Cabinet papers and minutes as well as the telegrams and dispatches of the Foreign Office. She has an office and a number of private secretaries who help her deal with government ministers, government appointments for which her approval is needed, and correspondence with Commonwealth governments. The same office arranges all her speeches, visits, and other engagements.

The honours system. Two Honours Lists are published each year, one for New Year's Day, the other for the queen's official birthday on June 2, the anniversary of her coronation. These lists contain all the titles, distinctions and medals, which the queen bestows personally at ceremonies called *investitures* at Buckingham Palace. These honours include knighthoods and peerages as well as more modest honours such as the Order of the British Empire (O.B.E.) and various medals for long service or gallantry (see **Decorations, medals, and orders**). Although the queen personally chooses a few of the people to receive honours, most honours are awarded on the recommendation of government committees. By tradition, such distinctions are highly prized and felt to convey an important status. But the honours system has also been criticized for its social bias.

Meeting the public. Each summer Queen Elizabeth II holds Royal Garden Parties in the grounds of Buckingham Palace or the Palace of Holyroodhouse in Edinburgh, her official residence in Scotland. Invitation to these occasions is mainly by the recommendation of committees and is also regarded as an honour.

Her other main public appearance every year is at the famous spectacle of trooping the colour on the Horse Guards Parade in Whitehall, London (see **Trooping the colour**).

The queen and other members of the Royal Family pay hundreds of visits every year to all parts of the United Kingdom. They are invited to preside on important occasions such as the opening of a new hospital or the launching of a ship. The queen receives all ambassadors to the United Kingdom in audience, as well as visiting premiers or heads of state. With government approval, she makes state visits abroad, usually with her husband, Prince Philip, Duke of Edinburgh.

Work of the other Royals. The queen is well known for being hard-working. She regularly undertakes several engagements in a day, as well as reading official documents and working on correspondence. Other members of the Royal Family also carry out official functions and visits. Chief among them are Prince Philip, Prince Charles, and the Princess Royal (Princess Anne). The Duke of York (Prince Andrew), and Prince Edward, also share in the Royal Family's public activities. They and other members of the queen's family, including the Princess of Wales (Princess Diana), attend many charity functions and represent the queen both in the United

The Queen Mother is well loved by many people throughout the United Kingdom.

The queen is invited to take part in many important functions throughout the year.

Kingdom and abroad. Most members of the Royal Family serve as patrons of numerous organizations, especially charities.

At home

Royal houses. The queen has seven royal residences. Six of them are in or near London: Buckingham Palace, St James's Palace, Kensington Palace, Kew Palace, Hampton Court, and Windsor Castle. The seventh, the Palace of Holyroodhouse, is in Edinburgh. She uses only three of these residences regularly—Buckingham Palace, Windsor Castle, and Holyroodhouse. The queen also has two private residences where she and her family like to spend their holidays. They are Sandringham House in Norfolk, and Balmoral Castle in Grampian Region, Scotland.

Clarence House, near the Mall, in London, is where Queen Elizabeth, the Queen Mother lives. She also owns two Scottish homes—at the Castle of May and at Birkhall, near Balmoral. In the 1980's, Highgrove House in Gloucestershire was the main country residence of Prince Charles, Princess Diana, and their two sons. Prince Charles has lived there alone since he separated from Princess Diana in 1992. When in London, the Prince and Princess occupy separate quarters in Kensington Palace, at the west end of Kensington Gardens. The Princess Royal's home is Gatcombe Park, Gloucestershire.

Members of the Royal Family

Queen Elizabeth II and Prince Philip, Prince Charles, Diana, Princess of Wales, the Princess Royal, Prince Andrew, and Prince Edward each have a biography in *World Book.* This article provides information about other family members.

Queen Elizabeth, the Queen Mother (1900-   ), is the widow of King George VI. She comes of a Scottish noble family, the Bowes-Lyons of Strathmore, in Angus. Her husband George unexpectedly became king in 1937, following the abdication of his brother Edward VIII. They reigned until 1952, and after George's death she became the senior member of the present Royal Family. Her special status throughout the United Kingdom is not a matter of her title, or of age alone. She is seen and loved as a living link to a more glorious past, and to the years of World War II (1939-1945) when the monarchy became a symbol of the struggle for democracy and freedom.

Princess Margaret, Countess of Snowdon (1930-   ), the Queen's younger sister, was born in Scotland at Glamis Castle, ancestral home of the Bowes-Lyon family. In 1960, she married a well-known designer and photographer, Anthony Armstrong-Jones (now Lord Snowdon). The two children of this marriage are David (Viscount Lindley) and Lady Sarah Armstrong-Jones. The couple divorced in 1978, and Margaret has never remarried. In spite of ill-health during the early 1990's, she continued a career of public service.

The outer circle of the Royal Family consists of descendants of three of George V's other children, Henry (1900-1974), George (1902-1942) and Mary (1897-1965). Henry's son Richard, Duke of Gloucester (1944   ), now stands closest in the line of accession. He was trained as an architect, and has performed a wide range of royal tasks.

The two princes, William and Harry, attend a public function with their mother, Princess Diana.

George's descendants include Edward, Duke of Kent (1935-   ), Prince Michael of Kent (1942-   ), and Princess Alexandra (1936-   ). They and their respective families lead much quieter lives than the queen and her immediate relatives but they are also quite prominent in public service.

A third branch of the family is descended from George V's daughter Mary. She married Henry Lascelles, Earl of Harewood, in 1922, and her son George Lascelles, 7th Earl of Harewood (1923-   ), is the present head of that family. He gained distinction as the managing director of English National Opera.

History

The present Royal Family of the United Kingdom belongs to a ruling dynasty called the House of Windsor. But Queen Elizabeth II can trace her descent through Queen Victoria back to King George III and beyond. George III was a member of the German House of Hanover, which ruled Britain after 1714 in succession to the monarchs of the House of Stuart. Queen Victoria, who came to the throne in 1837, changed the name of the dynasty to the House of Saxe-Coburg and Gotha, the German royal family to which her husband Prince Albert belonged. In 1914, at the start of World War I, the United Kingdom went to war with Germany. In 1917, George V, Queen Victoria's grandson, acknowledging the anti-German feeling of the time, wished to show his patriotic fellowship with his British subjects and so changed his family's name to Windsor.

Crisis and war. Following George V's death in 1936, his son Edward VIII came to the throne. Edward's wish to marry a divorced American woman, Wallis Warfield,

Simpson, sparked a political scandal and a constitutional crisis. The United Kingdom government refused to accept Wallis Simpson as queen, and after only 11 months, Edward VIII gave up the throne. (See **Edward VIII**.)

Edward was succeeded in December 1936 by his younger brother King George VI. George's reign was overshadowed by World War II (1939-1945). George was ill-prepared for kingship and did not enjoy good health. But he and his wife Queen Elizabeth (later the Queen Mother) stayed in London during the worst of the German air raids and visited bomb-damaged areas. (See **George VI**.)

The new Elizabethan Age. King George VI and his queen helped restore the fortunes of the Royal Family, as did their daughter, Queen Elizabeth II. Elizabeth was crowned in June 1953, a year after her father's death, at a magnificent ceremony in Westminster Abbey. This was the first coronation to be televised live and was witnessed by millions of people. It coincided both with the return of postwar prosperity and the rise of mass interest in television. As a result, the event greatly influenced people's attitudes and is still well remembered. Her reign was hailed as a "New Elizabethan Age" of achievement and glory comparable to that of her ancestor Queen Elizabeth I (reigned 1558-1603).

Prince Charles's wedding to Lady Diana Spencer at Saint Paul's Cathedral in London in July 1981 was the most magnificent and most highly publicized event since the queen's Coronation. People saw it as reinforcing the continuity of the monarchy—a glorious future into the next century, guaranteed by the marriage of the heir to the throne. The couple had two children, William and Henry (in 1982 and 1984). Princess Diana was very popular during her early years as Princess of Wales. But by 1990, it became clear that she was unhappy in her marriage. In 1992, she and the Prince of Wales announced their separation.

Princess Anne married Mark Phillips in 1973. She has two children, Peter (1977) and Zara (1981). The couple divorced in 1992. In 1992, Princess Anne married Tim Laurence.

Prince Andrew married Sarah Ferguson in 1986, and again the wedding ceremony was lavish. The couple had two children, Beatrice and Eugenie (fifth and sixth in succession to the throne). In 1992, they separated for a year. They formally confirmed their separation in 1993.

The Royal Family in the 1990's faces some difficult issues. The most significant of them is whether Prince Charles can ever become king, especially if he divorces Princess Diana. Even in a modern secular society, the Church of England, of which he would be head, might be unwilling to accept a divorced man as monarch. In 1992, Queen Elizabeth said that she would continue to serve her people as long as she could. Some people believe this to mean that she does not intend to abdicate in favour of Prince Charles.

Another issue is how the United Kingdom pays for its Royal Family. The personal wealth of Queen Elizabeth II and her immediate family is not known but is thought to be very great. She also receives several million pounds annually from the government in a payment known as the *Civil List,* intended to pay for her expenses as head of state. Other members of the family also receive payments (see **Civil List**).

Apart from the Civil List payments, a further 80 per cent of the monarchy's annual expenses are paid directly by the state. This includes the upkeep of most of the Royal palaces, the Royal train, a Royal flight of aircraft, and the Royal Yacht *HMS Britannia.* These items cost tens of millions of pounds a year. The high level of security and protection for the Royal Family adds several million pounds more to the bill.

Some politicians saw the Civil List and the other payments as an unnecessary burden, made worse by the fact that the queen was not a taxpayer. In 1992, however, the queen volunteered to pay income tax from 1993. At the same time she agreed to reductions in the Civil List.

Some people believe that the Royal Family should be abolished as an institution. They consider that there is no further need for a monarchy in the 1990's. Australia and Canada are the largest countries in the British Commonwealth. Although the queen is officially their head of state, they have actively debated the idea of becoming republics. However, the defenders of the monarchy continue to emphasize its unique historical character and its great popularity. They also stress the great value of the work which the Royal Family regularly accomplishes for both government and nation.

Related articles in *World Book* include:

Andrew, Prince	Kings and queens of Britain and Ireland
Castle	Monarchy
Charles, Prince	Mountbatten, Louis
Coronation	Philip, Prince
Crown jewels	Princess Royal
Diana, Princess	Queen's birthday
Duke of Edinburgh's Award	United Kingdom, History of the
Edward (VIII of England)	Westminster Abbey
Edward, Prince	Windsor Castle
Elizabeth II	
George (VI of England)	

Royal Geographical Society is a British organization composed of people interested in geographical education and discoveries. It has the world's largest private map collection, which is open to the public, and a large library. The society organizes geographical research projects and sponsors scientific expeditions. In the past the society has promoted Livingstone's explorations in Africa, Scott's journey to the South Pole, and Hillary's successful ascent of Mount Everest. It publishes two magazines: *The Geographic Journal* and *Geographical Magazine.* The society is sometimes asked to arbitrate in disputes over international borders.

The society was founded in 1830. It now has about 10,500 members in many countries. Headquarters are in London.

Royal Greenwich Observatory. See Greenwich Observatory, Royal.

Royal Household of the United Kingdom includes officials who conduct the private business of the monarch and supervise all branches of court life. They have few powers of government. The *lord chamberlain* supervises the household. The *lord steward* controls household finances, and supervises the treasurer and the comptroller of the household. The *master of the horse* cares for the royal stables. The queen's chief attendant is the *mistress of the robes.* She attends the queen on state occasions. The *ladies of the bedchamber* are the queen's personal attendants. The original offices, for example, marshal, steward, and chamberlain, are

hereditary in some families. These officials act only on ceremonial occasions.

Royal Institution is a scientific society, founded in England in 1799. King George III granted the society a charter in 1800. Its purpose is to encourage scientific study and to spread technical knowledge. The society has about 1,500 members.

Many brilliant scientists have been connected with the Royal Institution. They include Sir Humphry Davy, who invented the safety lamp for use in mines, and Michael Faraday, who did important work in the field of electrical research. The institution receives funds from private contributions. The headquarters of the institution are in London.

Royal Irish Academy is the main learned society of Ireland. It has about 240 members. Each member is elected by existing academy members in recognition of academic distinction. The academy is governed by a president and council elected annually. It is financed by a government grant, sale of publications, and income from trust funds. The academy's library contains many of Ireland's most valuable old manuscripts.

James Caulfield, Earl of Charlemont, founded the academy in 1785. The Royal Irish Academy is at 19 Dawson Street, Dublin 2.

Royal Life Saving Society is a worldwide organization that works to educate the public in water safety and other lifesaving matters. The society sets courses of class instruction, swimming, and lifesaving. Instructors who have earned the society's diploma will visit schools and clubs to operate these courses. The four larger branches of the society in Australia, New Zealand, Canada, and the United Kingdom have programmes of instruction, and award a bronze medallion to people who pass tests in lifesaving. Smaller branches, called member branches, in other Commonwealth countries each have their own award programmes.

The Royal Life Saving Society was established in London in 1891. It opened a Sydney branch in 1895. Local branches of the society in Australia became independent in 1952.

Royal Melbourne Show in Australia, is held in September each year by the Royal Agricultural Society of Victoria at the royal showgrounds at Ascot Vale. More than a million people see the show each year. About two-thirds of the visitors come from Melbourne. The rest are country people. Livestock and farm machinery are displayed. The show began as a ploughing contest in 1848.

Royal Mile. See Edinburgh.

Royal Mint is the British government department responsible for the design and preparation of official coins, seals, medals, and decorations. The chancellor of the exchequer is responsible for the mint, and has the title of *master of the mint.* In practice, the deputy master and comptroller heads the mint's staff of about a thousand. This official is helped by an advisory committee. During the past 100 years, the Royal Mint has increased its production of coins from 25 million a year to nearly 2,000 million. Well over half of the output of coins is for other countries. These countries include British colonies and other countries of the Commonwealth, as well as the Republic of Ireland, Burma, Iceland, Jordan, and Uruguay.

A traditional ceremony, called the *Trial of the Pyx,* is held every year at the Goldsmiths' Hall in the City of London. At this ceremony, an independent jury tests the weight and composition of a sample of coins produced the previous year. The sample coins are placed in a special box, called the *pyx.*

A mint was established in London by the Romans. Starting A.D. 860, minting was continuous in London for more than a thousand years. The mint was housed in the Tower of London until 1811, when it moved to another

Minted coins are placed in bags at the Royal Mint, in Llantrisant, Mid Glamorgan, Wales. The mint's coining department also strikes thousands of medals and decorations each year.

building on Tower Hill. The Royal Mint completed a move to Llantrisant, in Mid Glamorgan, Wales, in 1975.

Royal Navy. See Navy.

Royal Pavilion, Brighton. See Brighton.

Royal Society is one of the oldest scientific organizations in the world. Its full title is the Royal Society of London for Improving Natural Knowledge. The organization was founded in 1660 to promote the natural sciences. Its membership consists largely of leading British and Commonwealth scientists in such fields as chemistry, engineering, mathematics, and physics. The society has over 1,000 members.

The society encourages scientific advancement by sponsoring lectures, awarding research appointments and grants, and honouring scientists with medals for their work. The society also works to improve education in science and mathematics. It maintains extensive contacts with scientific academies throughout the world and encourages scientists to work together.

The Royal Society has a library of about 120,000 books and 200,000 manuscripts. It publishes several journals, including *Philosophical Transactions* and *Proceedings.* Its headquarters are in London.

Royal tennis, also called *real tennis,* is an ancient, complicated form of tennis, first played by French kings about 600 years ago. Players use an unsymmetrical court with a *penthouse* (sloping roof), *tambour* (buttress), *dedans* (net-covered area for spectators), and *grille* (courtyard hatch). A net sags across midcourt. On the floor is a maze of lines with names such as *chase a yard worse than last gallery* and *hazard chase the door.*

Players hit a small, hard ball with what looks like a lopsided racket. Players need both fitness and skill to play well. A handicap system is used to enable less experienced players to compete with experienced, more skilful competitors.

There are only about 30 courts in the world, most of which are in Australia, France, the United Kingdom and the United States.

Royalist. See Civil War, English.

In royal tennis a player needs skill and experience in order to cut or slice the ball with the required delicacy.

Royce, Sir Henry (1863-1933), was a co-founder of Rolls-Royce, manufacturers of motorcars and aircraft engines. He merged his firm with that of Charles Rolls to form the famous company in 1904 (see Rolls, Charles Stewart). Royce designed the cars. One of the first of the high-quality cars manufactured by Rolls-Royce was the *Silver Ghost,* which appeared in 1906. In 1915, Royce produced the *Eagle* aero engine. He also designed the *Kestrel* engine, the forerunner of an engine built into many World War II fighters. Royce was born near Peterborough, England. His full name was Frederick Henry Royce. He was made a baronet in 1930.

Royalty, a commission. See Writing.

Royalty. See King and its *Related articles.*

RSL. See Returned Services League of Australia.

RSPCA is the oldest animal protection society in the world. It works to promote kindness and to prevent cruelty to animals. It has more than 3,000 branches in England and Wales, as well as branches in many Commonwealth countries. Its full title is The Royal Society for the Prevention of Cruelty to Animals. It is supported by subscriptions, contributions, and legacies.

The society employs about 250 uniformed inspectors in England and Wales. Their main tasks are to rescue animals in danger and to investigate cases of cruelty. The society runs hospitals and more than 60 clinics where it treats pets free of charge. It also has about 60 kennels where stray and unwanted animals are housed.

The society publishes two magazines: *RSPCA Today,* for its adult members, and *Animal Ways,* for children. Its lecturers visit schools to talk to children about looking after animals. The society campaigns against such activities as deer hunting and hare coursing. It makes awards for bravery in rescuing animals.

The RSPCA has headquarters in Horsham, Sussex, England. People over 18 can become members, and children can join as *animal defenders.* The members elect the controlling body, the Council. Arthur Broome, a London clergyman, founded the society in 1824. Princess (later Queen) Victoria became the first patron in 1835.

Ruahines are a range of mountains in the southeastern part of the North Island of New Zealand. They extend from a point a few kilometres south of the Taruarau River in the north to the Manawatu Gorge in the south. They rise to more than 1,500 metres above sea level.

Ruanda-Urundi was a United Nations trust territory in east-central Africa administered by Belgium. When the UN created the trust territory in 1946, Ruanda-Urundi covered about 54,000 square kilometres, and about 5 million people lived there. In UN-supervised elections in 1961, Ruanda proclaimed itself a republic and Urundi established a monarchy. On July 1, 1962, the election results took effect and Ruanda became independent as *Rwanda,* and Urundi as *Burundi.*

Twa pygmies were the earliest inhabitants of Ruanda-Urundi. The Hutu (sometimes called Bahutu), a Bantu people, came from the Congo basin and forced the Twa into the forests. Then about 600 years ago, the tall Tutsi (sometimes called Watusi) from Ethiopia conquered the Hutu and began to rule the area.

British explorers Richard F. Burton and John H. Speke searched in the area for the source of the Nile in 1858. Henry M. Stanley and David Livingstone explored

around Lake Tanganyika in 1871. German explorers arrived later. Germany made Ruanda-Urundi part of German East Africa in 1899. The League of Nations gave Belgium a mandate over Ruanda-Urundi in 1923, and the United Nations made Ruanda-Urundi a Belgian trusteeship in 1946.

See also **Burundi; Kigali; Rwanda.**

Rubaiyat is a poem attributed to Omar Khayyam, a Persian poet, astronomer, and mathematician. It was probably written in the early A.D. 1100's. The title comes from the plural of the Arabic word *rubai,* which refers to a form of Persian poetry. A rubai is a *quatrain* (four-line stanza) that has a particular theme and develops a complete thought. The first two lines rhyme with the fourth line, or all four lines may rhyme. The word *rubaiyat* refers generally to any collection of such quatrains.

The *Rubaiyat* of Omar Khayyam consists of quatrains supposedly written by him. Through the years, more than 2,000 quatrains have been credited to him. However, he is known for certain to have written fewer than 200 of them.

The best known version of the *Rubaiyat* is the translation by the British writer Edward FitzGerald. FitzGerald's work was published in four editions—in 1859, 1868, 1872, and 1879. The final two editions each form a poem of 101 quatrains. The poem describes a pleasure-filled day from dawn to evening and has many moods. Some stanzas complain about the shortness of life and the injustice of the world. Others praise flowers, love, spring, or wine. One of the most quoted stanzas gives a pleasurable and uncomplicated view of happiness:

> A Book of Verses underneath the Bough,
> A Jug of Wine, a Loaf of Bread—and Thou
> Beside me singing in the Wilderness—
> Oh, Wilderness were Paradise enow!

About half the stanzas in FitzGerald's work are translations or paraphrases of quatrains attributed to Omar Khayyam. Nearly the same number combine parts of more than one quatrain. A few stanzas are based on quatrains of other Persian poets. In addition, FitzGerald composed a few stanzas in early editions of his translation.

See also **FitzGerald, Edward; Omar Khayyam.**

Rubber is one of our most interesting and most important raw materials. *Natural rubber* comes from the juice of a tree. *Synthetic rubber* is made from chemicals.

Rubber is especially useful for several reasons. It holds air, keeps out moisture, and does not readily conduct electricity. But its chief importance to us is that it is *elastic.* When you stretch a rubber band and let it go, its elasticity makes it quickly spring back to its original shape. A rubber ball bounces because of this same springiness. Your rubber heels absorb shock when you walk because they have elasticity.

We depend so much on rubber that it would be almost impossible to get along without it. This is not the case with most other materials. If we lack one material, we can usually substitute another. A house can be built using such materials as wood, brick, stone, concrete, glass, or metal. Clothes can be made of cotton, silk, wool, or other fibres.

But what about the tyres of a car, truck, or bus? It is hard to imagine making them of anything but rubber. Only rubber is elastic, airtight, water-resistant, shock-absorbing, and long-wearing.

Manufacturers make between 40,000 and 50,000 rubber products. A typical car has about 600 rubber parts. Some cars, of course, use less rubber than this, and some use more. Many trucks and buses even have springs made of rubber instead of steel.

Uses of rubber

More than half of the rubber used in the world goes into tyres and tubes. These are used on cars, aeroplanes, bicycles, buses, trucks, tractors, and construction machinery. Rubber is also used for mechanical products such as gaskets, sealing devices, belting, and printing rollers.

Manufacturers use rubber to make waterproof aprons, boots, raincoats, gloves, and hats, and to give elasticity to other types of clothing and household fabrics. Hard-rubber goods include hair combs and car-battery cases. Doctors use rubber hot-water bottles, ice bags, syringes, elastic tapes, and surgeon's gloves. Hearing aids, oxygen tents, and many other pieces of equipment have rubber parts.

Swimmers wear rubber bathing suits and caps, goggles, and ear plugs, and sun-bathe on rubber rafts. Many sports are played with rubber balls that range in size from small golf balls to large beach balls. Other rubber products include thread, bottle stoppers, toys, jar rings, elastic bands, and rubber-based paints.

Air pockets in sponge and foam rubbers make them springy. Manufacturers use such kinds of rubber for cushions, mattresses, pillows, and upholstery padding. They are also used as an insulating material. For example, some shoes have a layer of foam rubber next to the leather to keep out the cold.

Rubber cement can be used to hold pieces of paper together, but the pieces can be pulled apart easily. This cement is made of a solution of raw natural rubber in a chemical solvent. The solvent evaporates, and the sticky rubber holds the pieces of paper together.

The development of rubber

First uses. When the early European explorers came to Central and South America, they saw the Indians playing with bouncing balls made of rubber. According to an early Spanish historian, Christopher Columbus found the Indians of Haiti using balls "made from the gum of a tree." But later historians doubt this account, because it was written more than a hundred years after Columbus made his voyage.

The explorers learned that the Indians made "waterproof" shoes from *latex,* the milky white juice of the rubber tree. They spread the latex on their feet and let it dry. The Indians also made waterproof bottles by smoothing latex on a bottle-shaped clay mould. They dried the latex over a fire, and then washed out the clay.

The South American Indians called the rubber tree *cahuchu,* which means *weeping wood.* The drops of latex oozing from the bark made them think of big white tears. A French explorer, Charles Marie de La Condamine, gathered samples of hardened latex in Peru in 1735, and took them back to France. The French called this new material *caoutchouc,* the French pronunciation of the Indian name *cahuchu.* Variations of the French

Natural rubber comes chiefly from rubber trees grown on plantations in hot, moist regions. Workers remove a white juice called *latex* by cutting grooves in the bark, *above.* Latex, which is about one third rubber, is refined to produce crude rubber.

Synthetic rubber is made by mixing chemicals to produce latex that looks like natural latex from rubber trees. Manufacturers make some synthetic rubber in crumb form, *above.* Synthetic rubber performs better than natural rubber in many ways.

spelling are used as the word for rubber in most European countries. In 1770, the English chemist Joseph Priestley discovered that the material could be used as an eraser to *rub* out pencil marks. From this use, we get the name *rubber.*

The rubber industry begins. By the late 1700's, scientists had found that hardened latex dissolved in turpentine made a waterproofing liquid for cloth. In the early 1820's, the English inventor Thomas Hancock built what he called a "pickle machine" to knead scraps of rubber into a solid mass. His inventions and experiments led to the development of present-day rubber processing.

In 1823, Charles Macintosh, a Scottish chemist, began manufacturing the "mackintosh" raincoats that became world-famous. He made them with a layer of rubber between two layers of cloth. Manufacturers in Europe and the United States began to make many rubber products, including elastic bands, raincoats, hoses, tubes, and shoes.

Discovery of vulcanization. Early rubber products became sticky in hot weather, and stiff and brittle in cold weather. In 1839, Charles Goodyear, an American inventor, discovered a way to make rubber stronger and give it resistance to heat and cold. Goodyear accidentally spilled a sulphur-rubber mixture containing other ingredients on a hot stove while conducting an experiment. The rubber compound was "cured" by the heat, and stayed tough and firm in heat and cold. The process of heating sulphur-rubber mixtures became known as *vulcanization,* after Vulcan, the Roman god of fire. With vulcanized rubber, manufacturers could make dependable products, and the rubber industry grew rapidly. Vulcanized rubber was elastic, airtight, and watertight. It could be used to make tight seals between the moving parts of machinery.

The first plantations. At first, manufacturers used only wild rubber. Most of it came from the Amazon Valley of Brazil, although some was from latex-bearing vines in Africa. At the request of the British government, an amateur botanist named Henry A. Wickham took about 70,000 seeds of the *Hevea brasiliensis* tree from Brazil to England in 1876. About 2,500 of the seeds sprouted in a greenhouse at Kew Gardens near London. The seedlings were taken to Ceylon (now Sri Lanka) and Malaya for replanting on plantations. Almost all the plantation trees in the Far East come from these seed-

Interesting facts about rubber

"Champion" rubber trees can produce more than 10 kilograms of rubber a year.

Consumption of rubber in the United States is about four times as great per person as in the rest of the world.

Rubber can be made so elastic that it will stretch to more than nine times its normal length.

Rubber plantations throughout the world cover over 9.2 million hectares.

Synthetic rubber is made from chemicals obtained from such raw materials as petroleum, natural gas, coal, coke, grain, and potatoes.

Thomas A. Edison once made rubber from the latex of a giant goldenrod plant.

World's largest tyre in regular production contains over 3,200 kilograms of natural rubber. It is used in mining operations in North America.

World production of synthetic rubber increased more than tenfold during 1941 to 1944 because of the war effort.

Tyre production ranks as the chief use for most of the world's rubber. Most tyres contain both natural and synthetic rubber. The largest tyres consist of more natural than synthetic rubber. Car tyres contain more synthetic rubber.

lings. The British, Dutch, and French developed plantations in Indonesia, Thailand, Indochina, and other countries of the Far East.

The invention of the car in the late 1800's created a tremendous demand for rubber. Planters in Malaya and Ceylon set out 40,000 hectares of hevea trees in 1905, or almost twice as many as they had planted since 1876. By 1914, the yearly production of plantation rubber exceeded that of wild rubber. Later, plantations were established in Africa, South and Central America, and the Philippines.

Development of synthetic rubbers. The importance of rubber in wartime became obvious during World War I (1914-1918). Armies needed rubber-tyred vehicles to carry troops and supplies to the front. The Germans were cut off from their natural-rubber supplies by the Allied blockade, and began to make synthetic rubber. But it did not work as well as they had hoped. Experiments in producing synthetic rubber were continued in the 1920's, chiefly by scientists in Germany and the United States.

When World War II began in 1939, Germany was manufacturing two chief types of synthetic rubber: (1) *Buna S,* made from *butadiene* (a gas) and *styrene* (a liquid made from coal tar and petroleum); and (2) *Buna N,* made from butadiene and acrylonitrile (a liquid obtained from acetylene and hydrocyanic acid). Before 1939, experimenters in the United States made small amounts of several types of synthetic rubber in order to find a substitute for natural rubber. However, the estimated cost of making these synthetic rubbers was much higher than that of natural rubber. For this reason, manufacturers still produced most products from natural rubber.

The United States produced only about 8,200 metric tons of synthetic rubber in 1941. The Japanese captured the rubber-growing lands of the Far East in 1942. This cut off nine-tenths of the natural-rubber supply to the United States. Almost overnight, the United States developed a great synthetic-rubber industry. The American government built plants to produce GRS (Government Rubber-Styrene) and the styrene and butadiene needed for it. Rubber manufacturers and chemical companies operated the plants and pooled their knowledge about synthetic rubber. They worked with the government to develop ways to make as much synthetic rubber as they could, and as quickly as possible.

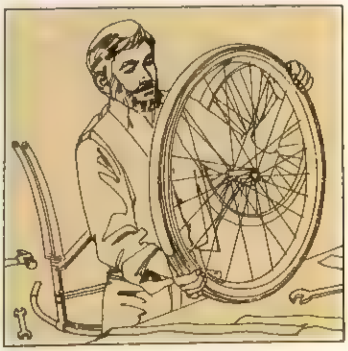
By the end of World War II in 1945, rubber production capacity in the United States had jumped to about 1,090,000 metric tons a year. The U.S. government sold its synthetic-rubber manufacturing plants to private companies in 1955.

The rubber industry

Production and uses. About 85 per cent of the world's natural rubber grows on plantations in the Far East, chiefly in Malaysia and Indonesia. Other Far East-

The original users of rubber were the Maya and other Latin-American Indians. They made rubber shoes by dipping their feet in latex and letting the latex dry on them, *above.*

Vulcanization was discovered by Charles Goodyear in 1839. He spilled a mixture of rubber and sulphur on a hot stove during an experiment. He found that heat strengthened the compound.



Pneumatic tyres were developed by John Dunlop of Great Britain in 1888. He first made the air-filled tyres, which provided a smoother ride than solid rubber ones, for the wheels of his son's tricycle.

ern countries that produce natural rubber include Burma, Cambodia, China, the Philippines, Thailand, and Vietnam. India and Sri Lanka grow about 8 per cent of the world's supply of natural rubber, and Africa grows about 5 per cent. The remaining supply of the world's natural rubber comes from South America. The world's production of natural rubber is about 5.1 million metric tons a year. The United States uses about 865,000 metric tons of natural rubber annually.

Production of synthetic rubber increased steadily after World War II. Before it's breakup in 1991, the Soviet Union was the world's largest producer of synthetic rubber. The United States then became the largest producer of synthetic rubber. About two-thirds of the rubber used in the United States is synthetic. Other important producers of synthetic rubber include, in order of production, Japan, France, and Germany. During the late 1980's, the world's annual production of synthetic rubber was about 10 million metric tons a year.

The world now uses more synthetic rubber than natural rubber. This is because synthetic rubber has a greater variety of uses and can be produced cheaply enough to compete with the cost of natural rubber. But the rising cost of petroleum, used in making synthetic rubber, has slowed the growth of synthetic rubber production. Synthetic rubber production has also been affected by the increasing popularity of radial tyres. These tyres require more natural rubber than do standard tyres.

Leading rubber manufacturers usually grow part of their natural rubber on their own plantations, and produce synthetic rubber in their own plants. These rubber companies make varied products such as tyres, mechanical goods, industrial products, shoe materials and footwear, aircraft parts, and rubberized textiles. Some companies also produce, for their own use and for sale to other firms, raw materials used to make synthetic rubber. More rubber is used in the manufacture of tyres than for any other purpose. The number of tyre manufacturers decreased during the 1980's as large companies bought smaller companies. Today, the two largest tyre manufacturers in the world in sales are Michelin, a French company, and the Goodyear Tire & Rubber Company of the United States.

Natural rubber

Latex is found in a wide variety of trees and other types of plants. You can see latex oozing from the broken stem of a dandelion or from a cut branch of goldenrod. Latex is still something of a mystery to scientists. Scientists know that latex is not a sap, but they are not sure of its use to the plant. Some scientists believe that latex acts as a kind of protective substance when a plant has been wounded.

Chemical analysis shows that about 30 to 35 per cent of latex consists of pure rubber. Water makes up another 60 to 65 per cent. The remainder consists of small amounts of other materials such as resins, proteins, sugar, and mineral matter. Latex holds little *globules* (particles) of rubber in the same way that milk holds butterfat. Latex spoils easily, and must therefore be processed into *crude rubber* as soon as possible after it has been tapped. This is done by separating the natural rubber in the latex from water and other materials. About 99 per cent of all natural rubber comes from the latex of the *Hevea brasiliensis*. This is the tree that we call the *rubber tree*.

The rubber tree. The hevea tree grows best in hot, moist climates in acid, well-drained soils. The finest rubber-growing regions lie within a *rubber belt* that extends about 1,100 kilometres on each side of the equator. Almost all natural rubber comes from huge plantations of rubber trees in the Far East.

The rubber tree cultivated on plantations grows straight and slender, about 18 to 20 metres tall. It has smooth, light-coloured bark and shiny, dark leaves. When its pale yellow blossoms fade, seed pods grow in their place. Each pod contains three brownish, speckled seeds about 2.5 centimetres long. The latex containing the rubber flows through a series of tubes in the tree's *cambium layer,* the outer wood layer directly under the bark. When this layer is pierced, the milky white latex oozes out. Botanists work continually to improve the hevea tree. By grafting and breeding, they have developed trees that produce over 10 times as much natural rubber as the wild hevea. Yields can also be increased by applying stimulants to the trees.

Rubber has also been collected from *landolphia* vines that grow in Africa. In Mexico, *guayule* bushes have been cultivated for their rubber, but they produce only a small amount. In Brazil, a small amount of rubber comes from wild hevea trees. Other rubber-bearing trees include the *manihot* tree, also found in Brazil, and the trees of the genus *Castilloa* found in Central America, Colombia, and Ecuador.

Tapping the tree. Rubber plantations employ workers called *tappers* who collect latex from the trees. Workers start tapping trees at daybreak, because the

Leading natural rubber producing countries

Malaysia	1,300,000 metric tons
Indonesia	1,200,000 metric tons
Thailand	1,165,000 metric tons
India	315,000 metric tons
China	258,000 metric tons

Figures are for 1990. Source: International Rubber Study Group, London.

Leading synthetic rubber producing countries

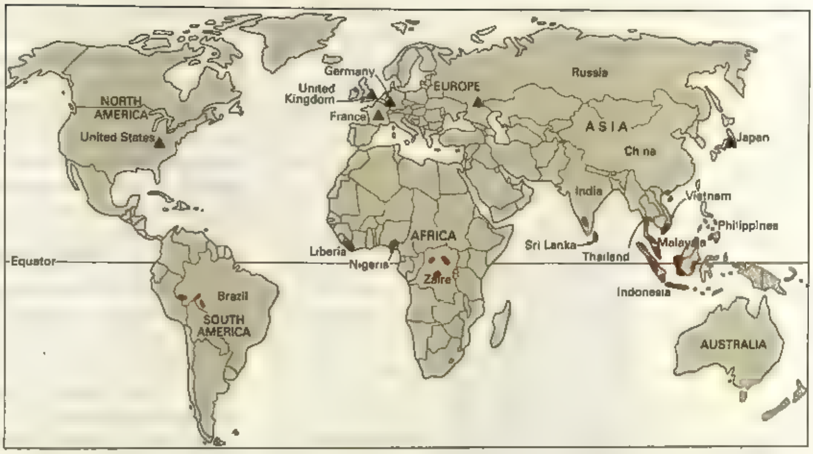
Soviet Union	2,427,000 metric tons
United States	2,087,000 metric tons
Japan	1,400,000 metric tons
France	528,000 metric tons
Germany	515,000 metric tons

Figures are for 1990. Source: International Rubber Study Group, London.

Rubber comes from two main sources. Natural rubber is provided chiefly by rubber trees grown on plantations in hot, moist areas. Synthetic rubber is manufactured in many industrialized nations. The map shows the leading countries for each type of rubber production.

Natural rubber harvesting areas

▲ Synthetic rubber producing countries



latex flows most freely in the cool morning air. They carry a *gouge,* a long, sharp knife with a curved blade. A tapper cuts a narrow groove in the bark of a tree about 1.2 metres above the ground. The groove slants diagonally downward about halfway around the trunk. At the bottom of the cut, the tapper attaches a U-shaped metal spout, and below it, a small cup. Latex oozes from the cut and flows down the groove through the spout. The spout directs the juice, drop by drop, into the cup. Each tapper works on about 350 trees on one round of tapping. This task takes about three hours. After tapping the last tree, the tapper makes a second round to collect the latex. About a teacupful of latex is collected at each tree. The tapper empties the cups into a large pail and carries the latex to the plantation's collecting station. The latex is transported to the factory for processing into liquid latex or dry rubber.

Some plantations tap the trees every other day. Other plantations tap every day for 15 days, and then allow the trees to "rest" for 15 days. On each tapping, the worker slices off a thin shaving of bark from the bottom edge of the groove near the cambium layer. The tapper does not cut into the cambium layer, because deep cuts that go into the wood harm the tree. After about three or four years, the groove reaches the ground, and the tapper cuts the bark on the opposite side of the trunk. By the time the second groove reaches the ground, the bark has grown back on the first groove, and it is ready to be tapped again.

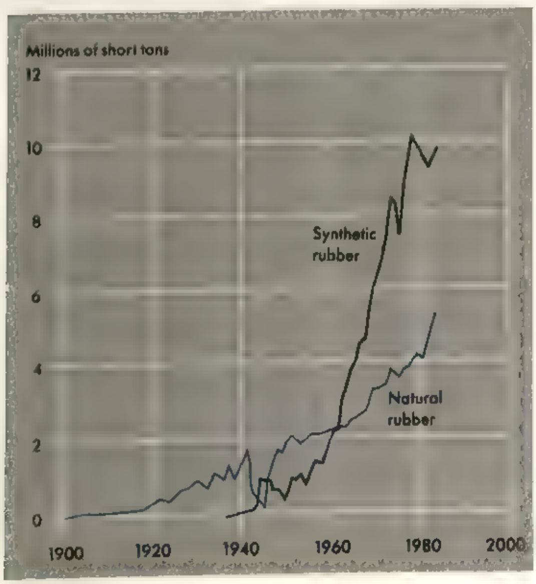
Workers begin to tap rubber trees about five to seven years after planting. But young trees do not give so much rubber as they do in their tenth year, when they are fully grown. Rubber trees yield their full capacity of latex for about 25 to 30 years. About 250 trees grow on one hectare, and each full-grown tree produces from 4 to 15 litres of latex per year. One hectare of trees on a large, well-developed plantation may yield more than 2,300 kilograms of dry crude rubber a year.

Separating the latex. Most plantations make crude rubber from latex by *coagulation.* Tappers pour latex from their collecting pails into tanks, and add an equal amount of water. They strain the diluted latex through sieves to remove dirt and bits of bark or twigs that may have fallen in during the tapping process. Formic acid is then added to the strained latex to make it *coagulate,* or form solid particles. Acid thickens latex in much the same way that vinegar curdles milk. The rubber particles rise to the surface of the liquid and form a curdlike white mass of crude rubber.

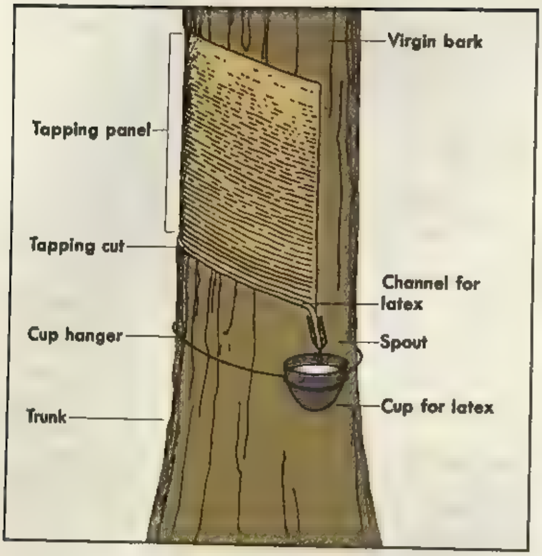
World production of rubber

Year	Natural rubber in metric tons	Synthetic rubber* in metric tons
1900	45,000	—
1910	98,000	—
1920	348,000	—
1930	838,000	—
1940	1,440,000	43,000
1950	1,890,000	583,000
1960	2,035,000	2,021,000
1970	3,103,000	5,893,000
1975	3,315,000	6,855,000
1980	3,850,000	8,690,000
1984	4,250,000	8,950,000
1990	4,925,000	9,885,000

*China and the Soviet Union included from 1962.
Source: International Rubber Study Group, London.



How a rubber tree is tapped



This diagram shows how latex is obtained from a rubber tree. The liquid oozes down to the spout through the channel produced by the tapping cut. It flows down the spout into the cup.

Processing crude rubber. Workers feed the crude rubber through rollers that squeeze out the water and form it into a sheet. *Crumb rubber* is produced by special machines that chop or shred the sheets into fine, wet crumbs. The crumb rubber is dried in hot air tunnels and then compressed into 34-kilogram bales for shipment to market.

Ribbed smoke sheet is made by putting crude rubber through rollers that give the sheets a ribbed appearance. The sheets are hung to dry for several days in a hot smokehouse. The smoke turns the rubber brown and kills mould and bacteria that would damage it. The dried sheets are pressed into bales and shipped to market.

Pale crepe rubber is formed by passing the curdlike mass through rollers that roughen and crinkle the sheets so that they look like thick crepe paper. The rubber is constantly washed while being rolled. The sheets hang in heating rooms and turn pale yellow while they dry. The sheets keep this colour if a chemical preservative is added to the latex. Workers bale the pale, crinkled sheets for shipment. *Crepe rubber* is often used in the soles of shoes. *Amber crepes, brown crepes,* and *flat-bark crepes* come from poorer quality sheets that have had less careful preparation.

The oldest method of making crude rubber from latex is by drying the latex over a smoky fire. This method still supplies the small amount of rubber that comes to market in the form of large, black balls called *biscuits.* To form a biscuit, a worker dips a wooden paddle into fresh latex and holds it over a smoky fire. After heat and smoke dry the latex, the worker re-dips the paddle and smokes a new coating. Many layers of dried latex build up until a large biscuit of crude rubber forms.

Processing latex. Sometimes, all the latex collected on plantations is not coagulated. Workers place part of the fresh latex in machines called *separators,* similar to those used by dairies to separate cream from milk. These machines remove part of the water from the latex. Ammonia or some other preservative keeps the latex from coagulating and prevents spoiling. The preserved liquid latex is sent to market in drums or tanks. Rubber manufacturers use latex to make articles such as surgeon's gloves, foam-backed carpeting, tubing, elastic thread, and furniture upholstery.

Manufacturing rubber products

Manufacturers obtain bales of dry rubber from plantations and from synthetic-rubber manufacturing plants. Latex comes to them in big tanks on ships and in tanker trucks. Manufacturers usually process natural and synthetic rubber in much the same way, although latex requires different steps.

Plasticization involves only dry rubber. It is a series of processes that makes dry rubber softer and more *plastic,* or easier to mould.

Workers first slice the big bales into small pieces of rubber that they can handle easily. The lower grades of natural rubber receive a thorough washing in a wringer-like machine called a *wash mill.* Then the rubber slices are fed into mixing mills and other machines that *plasticize,* or soften, them into a doughlike mass. Manufacturers plasticize the rubber faster by heating it and adding materials called *plasticizers* and *softeners.* Machines for plasticizing include (1) roll mills, (2) internal mixers, and (3) plasticators.

Roll mills usually consist of two rotating cylinders that turn toward each other at different speeds. The slices of rubber are placed on rolls that pass between the cylinders. The pressure of the rolls squeezes and flattens the slices into a doughy sheet that sticks to the slow-moving

Freshly tapped latex flows from a tanker truck into vats at a processing plant, *above.* The plant uses a process called *coagulation* to remove impurities from latex and form crude rubber.

cylinder. Cutting the sheet and doubling it on top of the rolls makes it possible to rework the rubber several times until it reaches the desired degree of softness.

Internal mixers work more rapidly than roll mills, and plasticize larger batches. One type, called the Banbury mixer, works somewhat like a roll mill. But the two rotating cylinders knead the rubber inside an enclosed chamber. Instead of being smooth, each cylinder has a spiral-shaped ridge along its surface. Thus, the rubber is kneaded in two ways: (1) by the two cylinders as the rubber passes between them, and (2) by the spiral-shaped ridge on the cylinder as it squeezes the rubber against the chamber wall. It operates much like the mixer that a baker uses to knead dough.

Plasticators operate on the same principle as meat mincers. Each has a large barrel-like chamber enclosing two *threaded*, or spirally grooved, rolls called *screws*. As the screws rotate, they work a continuous strip of rubber between their threads and the inside of the cylinder.

Compounding and mixing. Compounding means adding carefully measured amounts of various ingredients to plasticized rubber and to latex. The compounding "recipe" helps control the elasticity, strength, and other properties of the final product. The chief ingredients used in compounding dry rubber are (1) sulphur, (2) accelerators, (3) pigments, (4) antioxidants, (5) reclaimed rubber, and (6) fillers.

Sulphur is the principal ingredient most commonly used to bring about *vulcanization*, a process that takes place later in rubber manufacturing.

Accelerators are added to the rubber to speed vulcanization. They also improve the properties of the final product, and help make it uniform throughout. A variety of chemicals serve as accelerators.

Pigments, such as carbon black, make the rubber stronger and give it greater resistance to wear (see **Carbon**).

Antioxidants protect rubber against chemical changes and the harmful effects of heat, sunlight, and air. Some chemicals prevent cracking caused by ozone and oxidation (see **Oxidation; Ozone**).

Reclaimed rubber is obtained by treating waste rubber, such as old tyres, with heat and chemicals. This treatment makes rubber compounds softer and easier to handle so they can be reworked on mills and other equipment. The rubber compounds can then be revulcanized. In some places, reclaimed rubber is used in place of crude rubber.

Fillers may be added to dry rubber to increase its volume and to make a stronger, more flexible product. *Neutral*, or *inert*, fillers such as clay make the compound easier to handle, but do not increase the compound's strength.

Shaping. Manufacturers use several methods to shape rubber into final products. These include (1) calendering, (2) extrusion, (3) moulding, and (4) dipping.

Calendering means rolling rubber into sheets. It is done on a machine that has two to five rolls mounted one above the other. A conveyer belt carries the rubber from a roll mill to the top roll of the calender. The rubber passes between each pair of rotating rolls. They press it into a continuous sheet that comes off the lowest roll. Steam or cold water runs through the rolls to regulate the temperature. If the rolls are too hot, the rubber sheets will blister. If the rolls are too cold, the sheets will be too rough. Workers adjust the spacing between the rolls to form sheets as thin as 0.025 millimetre, or as thick as 5 millimetres. They cut the sheets into various sizes and patterns, or stack the sheets in

Sheets of crepe rubber, *above,* are formed by rollers that roughen and crinkle doughy masses of crude rubber passing through them. The rubber is constantly washed as it is rolled.

Washed and shredded rubber is dried at the processing plant by an *extrusion-dryer, above.* The dried rubber is baked and pressed into bales for shipment to rubber manufacturers.

layers to make many products. These products include rubber flooring, toys, bed sheets, baby pants, and mechanical goods such as wrapping tapes, washers, rings, and discs.

Extrusion is the final step in the processing of some rubber products. The word *extrude* means to push out. *Tube machines* push soft rubber through a hole, much as toothpaste is squeezed from a tube. The shape of extruded rubber depends upon the shape of the hole through which the rubber is pushed. Extruded products include hoses, inner tubes, and rubber strips used on refrigerator doors and car windshields. Extruded products are vulcanized after they have been formed.

Moulding produces shoe soles and heels, rubber tyres, hot-water bottles, mattresses, hard-rubber articles, and industrial products such as gaskets and fittings. Workers prepare pieces of rubber in the approximate size and shape of the finished product. They put the pieces in moulds shaped to form the final product. Many products are formed in moulds and vulcanized at the same time. During vulcanization, the rubber takes the exact shape of the mould in which it has been placed.

Dipping is used only to make products from liquid latex. Products made by dipping include rubber gloves and toy balloons. Workers dip moulds, usually made of metal, glass, or ceramic materials, into tanks of latex. They drain the excess latex, and dry the mould at low temperatures. By repeating this process, they build up several layers on the mould.

Vulcanization is usually the last step in preparing a final product. It gives strength, hardness, and elasticity to rubber by treating it with heat and vulcanizing agents such as sulphur. During vulcanization, the heat causes the sulphur to combine with the rubber and cure it. This makes the rubber stronger and more durable. Generally, the more sulphur that is added, the firmer the vulcanized compound will be. A compound containing one-third sulphur and two-thirds rubber vulcanizes to form *ebonite,* or hard rubber. Manufacturers use benzoyl peroxide instead of sulphur to vulcanize silicone rubbers. Many other vulcanizing agents exist, including tellurium, selenium, and certain benzene compounds. These agents are seldom used commercially, because they cost more than sulphur.

Vulcanization may take from a few minutes to several hours. Small products such as toys and shoe soles require about 5 to 7 minutes, but large products such as tyres take from 45 to 60 minutes. Compounds containing accelerators and sulphur vulcanize faster than plain sulphur compounds without accelerators.

Manufacturers vulcanize and shape moulded products at the same time by heating the moulds under pressure. They vulcanize extruded and sheet products on pans in hot-air or steam chambers. Dipped products are vulcanized in hot water, hot air, or open steam while still on the moulds. Foam products in their moulds are vulcanized in steam chambers or in boiling water.

Sponge rubber may be made either from dry rubber or from latex. *Blowing* produces one type of sponge rubber from dry rubber. During vulcanization, the chemicals that have been added turn to gas and "blow" tiny bubbles of air in the rubber compound. When the rubber *gels,* or sets, in the mould, the bubbles are trapped in it. Blown sponge rubber may be hard or soft.

Foam rubber is a type of sponge rubber made by whipping air into latex, much as a cook whips air into egg whites. Vulcanization takes place after the foam gels in a mould. Foam rubber has millions of tiny cells filled with air. Some types may be nine-tenths air and only one-tenth rubber. Foam rubber is used for upholstery and foam strips for surgical use.

Synthetic rubber

Rubberlike materials made from chemicals were called synthetic rubbers because they were intended as substitutes for natural rubber. Chemists use the word *elastomer* for any substance, including rubber, that stretches easily to several times its length, and returns to its original shape.

Manufacturers group synthetic rubbers into two classes: general-purpose and special-purpose. General-purpose rubbers have many uses. Special-purpose rubbers have special properties such as resistance to oils and fuels, air, and extreme temperatures, that make them better than natural rubber for certain uses.

General-purpose synthetic rubbers. The most important general-purpose rubber is styrene-butadiene rubber (SBR). It usually consists of about three parts butadiene and one part styrene. Butadiene, a gas, is made from petroleum. It must be compressed or condensed into liquid form for use in making rubber. Styrene is a liquid made from coal tar or petroleum.

Styrene and butadiene usually come to the synthetic-rubber plant in tankers. Sometimes they are piped in directly from the plants that produce them. Correct amounts of styrene and butadiene are pumped into a big tank containing a mixture of soap and water. The mixture is heated or cooled depending on the type of SBR being made. A catalyst causes the styrene and butadiene to combine with each other (see Catalysis). Gradually, with stirring, the ingredients change to a milky white fluid, also called *latex.* This synthetic latex looks much like natural latex.

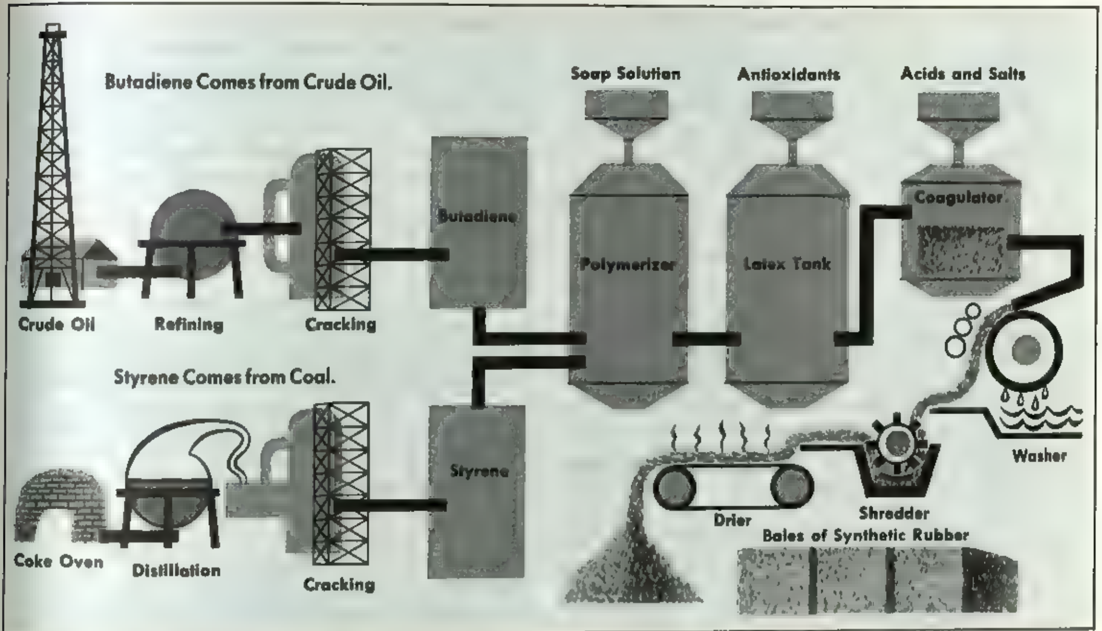
Workers pump the latex into another tank where antioxidants are added. Acids and salts are added to the latex in a third tank called a *coagulator.* The salts and acids coagulate the latex. The rubber forms into lumps that float on top of the liquid. Washing the rubber lumps removes extra chemicals. After drying, the lumps may be packed as loose crumbs or pressed into big bales of dry rubber.

SBR can also be prepared in a hydrocarbon solution. Metallic catalysts produce the reaction of butadiene and styrene to form SBR. The rubber is then recovered from the solution by evaporating the solvent.

Special-purpose rubbers. Contact with petrol, oils, sunlight, and air harms natural rubber. Special-purpose synthetic rubbers resist these "enemies" better than natural rubber or SBR do. Also, some of these special-purpose rubbers have greater resistance to heat and cold. They cost more than natural rubber or SBR, but their special properties make them worth the difference. Special-purpose rubbers include (1) butyl rubber, (2) cis-polyisoprene rubber, (3) neoprene rubber, (4) nitrile rubber, (5) polysulphide rubbers, (6) polyurethane rubbers, (7) silicone rubber, (8) ethylene-propylene rubbers, (9) fluorocarbon rubbers, and (10) thermoplastic rubbers.

How synthetic rubber is made

Most synthetic rubber is made from butadiene, a gas; and styrene, a liquid. These chemicals are combined with a soap solution and then undergo a process called *polymerization*, forming latex. Antioxidants are added to prevent the latex from decaying. The latex is then thickened by acids and salts in the coagulator to form rubber. The rubber is washed, shredded, dried, and baled.



Butyl rubber holds air and gases much better than natural rubber. It has wide use in inner tubes and in linings of tubeless tyres. It resists aging, heat, and the harmful effects of acids, and does not readily conduct electricity. The chief ingredients of butyl rubber include isobutylene (a gas) and isoprene (a liquid). Both are byproducts of petroleum refining.

Cis-polyisoprene rubber may eliminate our reliance on distant plantations for natural rubber. Its chemical composition is almost the same as natural rubber. It works just as well as natural rubber for products such as heavy truck tyres and heavy motor mountings. New catalyst systems have been developed to produce it.

Neoprene rubbers resist oxygen, sunlight, oil, petrol, and other chemicals better than natural rubber does. Their chief uses include petrol hoses, insulation for wire and cables that come in contact with oil, and gaskets for use as seals against oil or gas. Neoprene rubber is made from acetylene gas, which is produced by cracking petroleum fractions (see **Acetylene**).

Nitrile rubber (*Buna N*) has an especially high resistance to the harmful effects of petrol, grease, oil, wax, and solvents. It withstands heat (up to 177° C) much better than natural rubber and most synthetic rubbers. Nitrile rubber is used in petrol hoses, paper, leather products, and many types of cloth. It contains varying proportions of butadiene and acrylonitrile. Acrylonitrile comes from the chemical reaction of propylene, oxygen, and ammonia.

Polysulphide rubbers, such as Thiokol, have unusually good resistance to softening and swelling in petrol and greases. They also resist aging, air, and sunlight. Their chief uses are for lining petrol hoses, and for printing plates and rollers. Ethylene dichloride and sodium polysulphide are the main ingredients of polysulphide rubbers.

Polyurethane rubbers resist age and heat, and withstand remarkable stresses and pressures. They can be made so tough that they will outlast natural rubber as materials for tyres. Manufacturers use them in large quantities, chiefly for upholstery, foam-rubber mattresses, and insulating materials. Polyurethane foams come in a great variety of types, from flexible to rigid, and from dense to light. The ingredients of polyurethane rubbers include ethylene, propylene, glycols, adipic acid, and diisocyanates.

Silicone rubbers keep their rubberlike properties at much higher and lower temperatures than natural rubber or any other type of synthetic rubber. They can be used at temperatures ranging from −90° to 316° C. Other rubbers become brittle and useless at such temperatures. Manufacturers use silicone rubbers in such products as seals, gaskets, and other parts of jet planes and machinery exposed to high temperatures. Silicone rubbers are made of oxygen and silicon, with a hydrocarbon added to the silicon.

Ethylene-propylene rubbers have a wide range of uses in the car industry. They have excellent resistance to oxygen and ozone and are especially resistant to high temperatures. They are made from ethylene and propylene, which are relatively inexpensive.

Fluorocarbon rubbers have excellent resistance to petroleum fluids and high temperatures. They are made from fluorinated organic compounds and are more expensive than most other rubbers.

Thermoplastic rubbers combine the strength of vul-

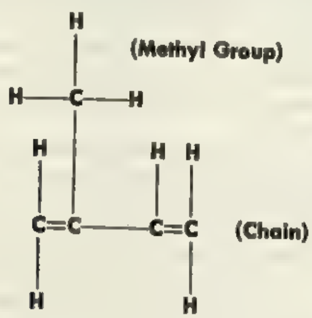
canized rubber with the processing ability of plastics. They are used in such products as shoe soles, car components, and adhesives.

The chemistry of rubber

The chemistry of natural rubber has presented a challenge to scientists. Why did vulcanization make rubber stronger? Could rubber be made synthetically?

In 1826, Michael Faraday, an English physicist and chemist, discovered that rubber is a hydrocarbon. That is, it belongs to a large family of substances that are composed of hydrogen and carbon. Other well-known hydrocarbons include petrol, motor oil, natural gas, and oil of turpentine. This explains why so many synthetic rubbers are made from petroleum products. See **Hydrocarbon.**

In 1860, another Englishman, Greville Williams, heated some rubber and obtained a colourless liquid that he called *isoprene*. Each isoprene molecule contains five carbon atoms and eight hydrogen atoms (C_5H_8). The atoms in the isoprene molecule always form a definite pattern. Four of the carbon atoms form a chain. The fifth carbon atom branches off from one of the carbons in the *chain*. Three hydrogen atoms surround the fifth carbon atom to form a *methyl group*. The following chemical symbols show the arrangement of the five carbon and eight hydrogen atoms in the isoprene molecule:



In natural rubber, thousands of tiny isoprene molecules link together in a giant, chainlike molecule, the rubber molecule. Chemists call such chainlike molecules *polymers,* meaning "many parts." They call single molecules, such as isoprene, *monomers*.

The particular chainlike structure of the rubber polymer explains why rubber is elastic. Polymer molecules of unstretched rubber fold back on themselves somewhat like irregular coils. Stretching the rubber straightens the chain of folded molecules. Releasing the rubber lets the chain return to its coiled position.

Sulphur combines with the rubber during vulcanization to set up "cross-links" between the rubber chains. The chains in unvulcanized rubber can slip, causing the rubber to be less elastic. During vulcanization, the cross-links bind the chains together so they cannot slip past one another. This gives elasticity and strength to the vulcanized product. However, if the cross-linking is carried too far, the cross-links tend to stop the unfolding of the chains. This reduces the elasticity of the rubber. The number of cross-links increases according to the amount of sulphur added to the compound. With large amounts of sulphur, rubber becomes stiffer, tougher, and less stretchable, until it turns into hard rubber.

Chemists believe that the characteristics of many rubberlike substances depend on the way their atoms are joined together. For example, they know that each carbon atom in a rubber molecule can combine with four other atoms. When the carbon atom holds four other atoms, it can hold no more. It is then said to be *saturated.* If it holds less than four atoms, it is *unsaturated.* Unsaturated atoms can hook on to other atoms.

Natural rubber has many unsaturated carbon atoms. Oxygen atoms from the air gradually attach themselves to these carbon atoms. This breaks down the rubber polymers so that the rubber becomes brittle or soft and loses elasticity. The addition of antioxidants during compounding prevents this action.

Scientists have not discovered all the answers to the chemistry of rubber. For example, they once believed that sulphur atoms attached themselves to unsaturated carbon atoms during vulcanization. But the sulphur reaction that makes rubber hard now seems more complicated than this. In many other ways, the chemistry of natural rubber remains a mystery.

The chemistry of synthetic rubber. For years, chemists tried in vain to duplicate the true rubber polymer with isoprene monomers. One big problem was to join isoprene monomers end to end to build up a long chainlike polymer, as in rubber. The carbon atoms in the centre of the isoprene monomer are unsaturated. The problem was to prevent the atoms in the centre from connecting with one another. Otherwise, the polymer would branch out at the side instead of joining at the end to form a long chain.

Scientists finally discovered how to approximate the giant polymer of natural rubber. The process for making synthetic rubber was difficult to discover, but is now rather simple.

Isoprene monomers make a difficult building block. This is why scientists made the first successful synthetic rubbers from the monomers of other hydrocarbons. These monomers included butadiene (C_4H_6), styrene ($C_2H_3C_6H_5$), isobutylene (C_4H_8), acrylonitrile (C_2H_3CN), and chloroprene (C_4H_5Cl). Each of these building blocks can be made in several different ways, from a wide variety of raw materials. Silicone rubbers are quite different from the other synthetic rubbers. The chain of the polymer is made of silicon and oxygen atoms instead of carbon atoms.

Research in rubber is directed mainly toward making better synthetic rubbers to provide improved rubber products for home and industrial use. In addition, many unusual types of rubber are required in the age of nuclear energy and space travel. As the new supersonic planes and missiles fly higher and faster, they require rubber parts that can withstand temperatures from −84 to 370 °C. Chemists hope to develop rubbers that will increase protection against nuclear radiation in atomic plants.

Researchers are also trying to develop rubbers that can be processed with a minimum of energy. For example, powdered or liquid rubbers would not require heavy-duty machinery for mixing or for manufacturing the products. U.S. scientists are studying the possible use of the guayule plant as an inexpensive source

of natural rubber. This plant could reduce their dependence on foreign sources of natural rubber and on synthetic rubbers made from petroleum.

Related articles in *World Book* include:

Agriculture	Guayule	Plastics
Elasticity	Indonesia (picture)	Polymerization
Faraday, Michael	Latex	Tyre
Goodyear, Charles		

Outline

I. Uses of rubber
II. The development of rubber
III. The rubber industry
A. Production and uses
B. Leading rubber manufacturers
IV. Natural rubber
A. The rubber tree
B. Tapping the tree
C. Separating the latex
D. Processing crude rubber
E. Processing latex
V. Manufacturing rubber products
A. Plasticization
B. Compounding and mixing
C. Shaping
D. Vulcanization
E. Sponge rubber
VI. Synthetic rubber
A. General-purpose synthetic rubbers
B. Special-purpose rubbers
VII. The chemistry of rubber
A. The chemistry of natural rubber
B. The chemistry of synthetic rubber
C. Research

Questions

Who first used the name "rubber"? Why?
What accident led to the discovery of vulcanization?
What country first developed synthetic rubber?
What countries grow the most natural rubber?
What is the greatest rubber-manufacturing city?
What is latex? Why is it said to be something of a mystery?
How does the chemical structure of rubber explain its elasticity?
How are rubber trees tapped?
What is crude rubber?
What country produces the most synthetic rubber?

Rubber plant is the common name for a house plant that is really a kind of fig. The rubber plant can grow well in the heat and low humidity of houses. It grows tall rapidly and lives a long time. The leaves of the rubber plant are large and broad and may grow from 5 to 30 centimetres long. The upper surface of the leaf is a shiny, dark green, and the under side is dull and lighter green.

The rubber plant is frequently grown in pots in the home. It has thick, rubberlike leaves.

The rubber plant requires little care. It will grow well if the soil in the pot is rich in minerals and the plant is given enough sunlight, water, and space. The plant should be placed outdoors during the summer so that it will get enough sunlight to last the winter. A rubber plant may grow so tall that it may be necessary to cut it back to make it branch. Sometimes a new plant can be grown from the tip of the stem that is cut off.

Rubber plants are often attacked by scale insects. These pests can be destroyed by spraying the plants with an insecticide. Commercial rubber does not come from these rubber plants, but from a tropical tree that belongs to the castor-bean family.

Scientific classification. Rubber plants are in the mulberry family, Moraceae. The common rubber plant is *Ficus elastica*. The more decorative rubber plant is the fiddleback fig, *F. lyrata*.

Rubbra, Edmund (1901-1986) was an English composer, pianist, and teacher. His large output of compositions includes eleven symphonies, other orchestral music, and choral music. He composed two masses—one Anglican and one for the Roman Catholic Church, which he joined in 1948. Rubbra was a senior lecturer in music at Oxford University from 1947 to 1968.

Rubbra was born in Northampton, Northamptonshire, and attended school there. He worked as a railway clerk before winning scholarships to Reading University and the Royal College of Music. His teachers included the composers Gustav Holst and Ralph Vaughan Williams.

Rubella is a common contagious disease that most frequently affects children. It is also called *German measles*. Most cases of rubella are not serious. However, if a woman develops the disease during early pregnancy, it may result in her baby having one or more birth defects. Such defects may include mental retardation, impaired vision and hearing, and malformations of the heart.

Rubella is caused by a virus, which is spread chiefly in droplets expelled when an infected person coughs or sneezes. Two to three weeks after contact with the disease, a person may develop a runny nose or mild fever. Pink, slightly raised spots appear on the face and spread to the trunk and limbs. Lymph nodes on the back of the scalp, behind the ears, and on the side of the neck may become tender. These symptoms usually disappear in a few days. In adolescents and adults, the symptoms often are more severe than in children and may include painful, swollen joints. In some cases of rubella, no symptoms appear. Infected people can spread the virus to others from about seven days before the rash develops until about five days after its appearance.

There is no specific treatment for rubella. A case of rubella results in *immunity* (resistance) to the disease for the rest of a person's life. In 1969, a vaccine became available that also provides immunity to rubella. Doctors recommend that children 15 months of age or older be given this vaccine and that a second dose be given from 4 to 12 years of age. It is generally combined with vaccines for measles and mumps.

See also **Measles**.

Oil painting on canvas (1623); The Louvre, Paris

Rubens' *Coronation of Marie de Médicis* was one of a series of pictures painted by the artist to glorify Queen Marie de Médicis of France and her late husband, King Henry IV. The painting shows the drama, rich colour, and vitality that characterized Rubens' baroque style.

Rubens, Peter Paul (1577-1640), was the greatest Flemish painter of the 1600's. In addition to his paintings, Rubens made designs for book illustrations and tapestries, and occasionally for architecture and sculpture. He was also a scholar and a respected diplomat.

His life. Rubens was born in Siegen, Germany, of Flemish parents. After his father died in 1587, his mother returned with her children to her native city of Antwerp.

Alathea Talbot, Countess of Shrewsbury (1620), an oil painting on canvas, Alte Pinakothek, Munich, Germany

A Rubens portrait shows an English countess attended by a dwarf, *left,* a jester, *right,* and an unidentified man. Most of western Europe's important nobility sat for Rubens' portraits.

There, Rubens studied under local painters. He moved to Italy in 1600 to study art. In Italy, he was employed as a painter by Vincenzo Gonzaga, duke of Mantua. In 1603, the duke sent Rubens to Spain as a member of a diplomatic mission. After returning to Italy, he continued his painting and his art studies.

Rubens went back to Antwerp in 1608, to visit his sick mother, but she died before he arrived. In Antwerp, Rubens was offered several important commissions for paintings, and he decided to remain in the city. In 1609, he married Isabella Brant, a member of a prominent Antwerp family. They had three children.

Also in 1609, Rubens became court painter to the Brussels court of Archduke Albert and the Infanta Isabella. Rubens' fame as a painter spread, and noblemen throughout Europe sought his services. He also received many commissions from churches.

To carry out commissions for large-scale works, Rubens trained several young artists as his assistants. However, he still completed much of the work himself. Rubens never claimed any of his assistants' pictures as his own unless he had retouched them thoroughly. His most famous assistant was the Flemish artist Sir Anthony Van Dyck.

After his wife died in 1626, Rubens accepted several diplomatic assignments involving peace negotiations between England and Spain. Rubens' assignments took him to Madrid in 1628 and to London in 1629. King Charles I of England knighted Rubens for his skill in diplomacy.

Rubens married again in 1630 and gradually withdrew from political life. His second wife was a beautiful 16-year-old girl, Hélène Fourment. Hélène, like Rubens' first wife, was a member of a prominent Antwerp family. Rubens painted her many times. They had five children. After 1635, Rubens spent much time at his country es-

tate near Brussels. The beautiful landscape scenes he painted there reflect his love for Flanders.

His art. The most important influence on Rubens' style was the ancient Roman sculpture he studied in Italy. He was also influenced by the paintings and sculptures of such Italian Renaissance artists as Michelangelo, Raphael, Tintoretto, Titian, and Paolo Veronese. Among the artists of his own time, Rubens especially admired Michelangelo Caravaggio and Annibale Carracci.

Rubens was the most important baroque artist of northern Europe. His paintings are known for their vast scale, brilliant colours, and emotional intensity. Rubens completed an enormous number of works. In one commission during the 1620's, he painted 24 large pictures on the life of Marie de Médicis, the widow of King Henry IV of France. From 1630 to 1635, he painted nine huge canvases for the Banqueting House at Whitehall in London. In the mid-1630's, he organized the artists of Antwerp to decorate structures in the city according to his designs to celebrate the visit of a new Spanish governor.

Rubens' subjects include hunting scenes, Biblical episodes, stories from classical mythology, portraits and self-portraits, and landscapes. *Elevation of the Cross* is an example of his baroque style. It is reproduced in the Painting article.

See also **Baroque; Daniel, Book of** (picture); **Drawing** (picture: A chalk drawing); **Jesus Christ** (picture: *Le Coup de Lance*).

Rubeola. See **Measles.**

Rubicon is a stream near Rimini, Italy, that Julius Caesar made famous when he was governor of Gaul. The Rubicon was part of the boundary between Roman Italy and the Roman province of Cisalpine Gaul (the Po Valley). Caesar and other Roman governors were forbidden to cross the boundary with troops. Caesar was commanding troops in Gaul when the Roman Senate, fearing his power, ordered him to give up his command. Caesar refused, and led his men across the Rubicon on Jan. 10, 49 B.C. This action symbolized the start of Caesar's successful drive for the leadership of Rome. The expression *to cross the Rubicon* means to make a decision that cannot be changed.

The name Rubicon comes from the Latin word *rubeus* meaning *red.* The stream got its name because its waters are coloured red by mud deposits. It may be the same river as the present-day Fiumicino River.

See also **Caesar, Julius.**

Rubidium is a chemical element with symbol Rb. It is a soft, silvery-white metal. The German scientists Gustav Kirchhoff and Robert Bunsen discovered it in 1861. Rubidium occurs abundantly in the earth's crust. But, it is so widely distributed that its production is limited. It is usually obtained from minerals used for lithium production. Industry uses rubidium as a catalyst, and in making photocells and electron tubes.

The atomic number of rubidium is 37, and its atomic weight is 85.4678. Rubidium oxidizes readily in air and is a fire hazard. It reacts violently with water and acids and melts at 38.84° C.

Rubinstein, Anton Gregor (1829-1894), was a Russian pianist and composer. He was one of the greatest pianists of the 1800's, and his tours through Europe and America also made him the most famous pianist of his time. Rubinstein composed many works, but few of them are performed today. Rubinstein was born near Balta, in the Ukraine. At 10, he made his first public appearance in Moscow.

When Rubinstein was 16, he began to teach in Vienna. Two years later he went to St. Petersburg. There the Grand Duchess Helen became his patroness and gave him many opportunities to be heard in public. In 1858, he became court pianist and concert conductor. The following year, he became director of the Royal Russian Musical Society, and four years later he founded the St. Petersburg Conservatory. He served as its director until 1867, and again from 1887 to 1890.

Rubinstein, Arthur (1887-1982), was a Polish-born concert pianist. He became famous for his warmly expressive interpretations of music by romantic composers of the 1800's, especially Frédéric Chopin. Rubinstein also gained praise for his performances of works by Franz Liszt, Robert Schumann, Peter Ilich Tchaikovsky, Manuel de Falla, and Heitor Villa-Lobos. In addition to his solo concerts, Rubinstein performed chamber music with other prominent musicians.

Rubinstein was born in Łódź, Poland. He studied in Berlin and Warsaw with the composer Max Bruch and the pianist Ignace Paderewski among others. Rubinstein made his concert debut at the age of 11. He moved to the United States in 1939 and became a United States citizen in 1946. Rubinstein wrote two autobiographies, *My Young Years* (1973) and *My Many Years* (1980).

Ruble. See **Rouble.**

Ruby is the red gem variety of the mineral corundum. Varieties of corundum are called *sapphires* if they are blue and *fancy sapphires* if they are any colour other than red or blue. Chemically, corundum is an aluminium oxide. Rubies get their red colour from traces of chromium in the aluminium oxide. The red of most rubies has a brownish or yellowish tint. But the most highly valued rubies have a bluish tint called *pigeon's blood red.*

Rubies and sapphires are second only to diamonds in hardness, and fine-quality rubies are among the costliest of all gems. The finest rubies come from Burma. Today, commercially important deposits are mined in Thailand. India produces many rubies of lesser quality, but its *star rubies* are excellent. A star ruby appears to have a six-rayed star within it when seen in a bright light. Rubies from Sri Lanka are generally pale in colour.

Millions of carats of inexpensive synthetic rubies are produced each year. However, a demand for real gems has allowed the natural stones to maintain their high value. It can be difficult to distinguish between natural and synthetic rubies, even for experts. Red garnets are sometimes used as substitutes for ruby, and they may appear under such misleading names as *Arizona ruby* or *Cape ruby.* The ruby is the birthstone for July.

See also **Corundum; Gem** (picture); **Laser** (Solid lasers); **Sapphire.**

Red ruby

Rudbeckia, also known as *coneflower,* is the name of about 25 species of medium to tall (30 centimetres to 2 metres) yellow-flowered plants of North America. Many are grown as ornamental plants for late-summer colour in flower borders. Common cultivated types include the *thimbleflower* and *black-eyed susan.*

Rudbeckias grow best in well drained soil in a sunny position. The dead flower heads should be removed to encourage new flowers to form. The plants should be cut down in late autumn.

Scientific classification. Rudbeckia belongs to the daisy family, Compositae (Asteraceae). It is genus *Rudbeckia.* The thimbleflower is *R. bicolor* and the black-eyed susan is *R. hirta.*

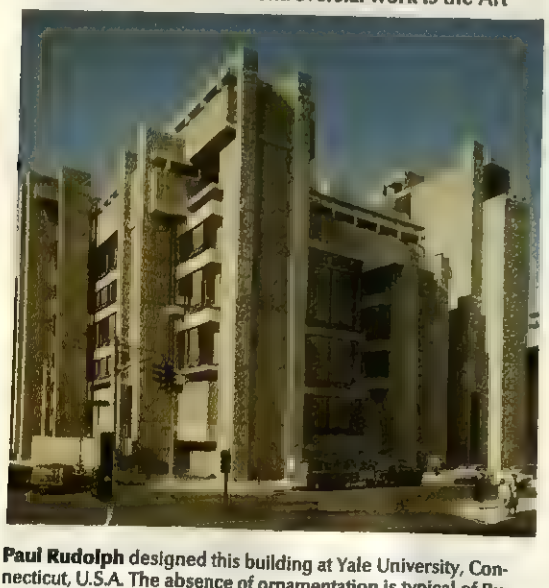
Rudd, Steele (1868-1935), was the pen name of Arthur Hoey Davis, an Australian author. Davis wrote many humorous short stories about struggling *selectors* (small farmers) in Australia. His own family were poor selectors and had to work hard to make a living out of the land. His books include *On Our Selection* (1899) and *Our New Selection* (1903). The two main characters, Dad and Dave, are among the most famous in Australian literature. Davis was born at Drayton, near Toowoomba, Queensland. The first of his stories about selectors appeared in *The Bulletin* in 1895. See also **Australian Literature.**

Rudder. See **Aeroplane** (Flying an aeroplane; The parts of an aeroplane); **Ship** (The chief parts of a ship); **Invention** (The Middle Ages).

Rudolf, Lake. See **Lake Turkana.**

Rudolph, Paul (1918-), is an American architect. He is best known for his dramatic and complex designs, especially for urban and academic environments. Rudolph's imaginative use of concrete and the absence of ornamentation in his exteriors show the influence of the modern French architect Le Corbusier (see **Le Corbusier**).

Rudolph served as chairman of the architecture department at Yale University in New Haven, Connecticut, from 1958 to 1965. Several of his important buildings are in New Haven. His most controversial work is the Art and Architecture Building (1963) at Yale, a complicated, 9-storey building with 36 interior levels. The Temple Street parking garage (1963) is an example of his skill in integrating structures into urban settings. It is also an attempt to turn a simple, functional building into an object of beauty. In the 1960's, Rudolph began to design low-cost, prefabricated residential buildings. Rudolph was born in Elkton, Kentucky.



Paul Rudolph designed this building at Yale University, Connecticut, U.S.A. The absence of ornamentation is typical of Rudolph's designs.

Rue is a type of herb, which grows as a low shrub. *Common rue* has deeply divided blue green leaves that have a very strong *acrid* (bitter) smell. The leaves are used sparingly to flavour meat dishes. The small yellowish flowers are borne on stiff upright flower stalks. About 40 species of rue are native to Europe and Asia.

Scientific classification. Rues belong to the family Rutaceae. Common rue is *Ruta graveolens.*

Ruff is a sandpiper native to the Eastern Hemisphere. During the mating season, the male develops a tuft of feathers on its neck that it can erect into a ruff. The birds range in colour from black and chestnut to buff and whitish. The female, called a *reeve,* has more modest plumage than the male.

The ruff is a sandpiper. In the mating season, the male, *above,* develops a tuft of neck feathers it can erect into a ruff.

Scientific classification. The ruff belongs to the sandpiper family, Scolopacidae. It is *Philomachus pugnax.*

Ruffed grouse is a thickly feathered grouse of North America. It is famous for the drumming sounds the male bird makes with his wings. He picks a special log for his drumming and can be heard early in the morning. For many years, naturalists thought that the bird drummed by beating his wings against the log, against his breast, or against each other. High-speed photographs have shown that the bird actually beats the air with his wings, creating a sonic boom. At first the sounds are dull and well spaced, but as the bird warms to his work, the drumming becomes a long roll. The sound can be heard for a great distance.

The male grows to about 40 centimetres long. A thick collar of feathers around the bird's neck gives him his name. These feathers are a gleaming black and can be lifted outward until they look like a ruff.

The ruffed grouse makes its nest at the foot of a tree.

A male ruffed grouse beats the air with its wings, *above,* making a drumming sound that can be heard far away.

The nest may be formed from leaves, and may contain from nine to 14 eggs.

The birds do not fly south in the autumn. In winter, the leg feathers of the grouse grow longer for warmth, and a weblike structure grows between its toes, enabling it to walk on top of snow.

Scientific classification. The ruffed grouse belongs to the grouse family, Tetraonidae. It is *Bonasa umbellus.*

See also **Grouse.**

Rugby (pop. 83,400) is an important railway junction and local government district in Warwickshire, England. The district includes a large agricultural area with mixed farming and dairy farming. But most of the district's people live in the town of Rugby, where the main industries include the manufacture of electrical equipment. It also has a powerful radio transmitting station.

Rugby School, a well-known independent school, was founded in 1567.

See also **Warwickshire.**

Rugby football is a fast contact sport played by two teams. Players on each team try to score by kicking, passing, or carrying the ball until they can kick it over the opponents' goal or touch it down behind the opponents' goal line. The team that scores the most points wins the match.

There are two versions of Rugby football—*Rugby Union* and *Rugby League.* Rugby Union, the older of the two, is only played by amateurs. Both types of Rugby football originated in the United Kingdom in the 1800's and both are now played throughout the world.

Both forms of Rugby football feature almost continuous play. Stoppages occur only when a player is injured, when points are scored, if the ball crosses the boundaries of the field, or when there is a restart of play resulting from a rules violation. A match is divided into two 40-minute halves separated by a half-time rest period of no more than 5 minutes. Rugby Union and Rugby League both involve tackling and other physical play, but players are allowed little protective equipment. A typical uniform consists of a shirt, shorts, knee-length socks, and cleated boots. Some players wear shin guards and mouth guards.

Rugby Union

Rugby Union has been described as "a game for ruffians played by gentlemen". The reference to "gentlemen" indicates that the game is played only by amateurs. In this it differs from the similar game of Rugby League, in which some players are professionals.

Rugby Union is popular in many parts of the world. It developed in England, soon spreading to Scotland, Wales, and Ireland. It became popular in Australia, South Africa, New Zealand, and France. It also developed to a somewhat lesser extent in Canada, the United States, Italy, Romania, Japan, the Soviet Union, Fiji, Argentina, and more than 90 other countries.

The field and equipment. The field is a maximum of 69 metres wide and 144 metres long. The goal lines are 100 metres apart. An area called the *in-goal* extends up to 22 metres beyond each goal line. A halfway line and other lines parallel to the goal lines divide the field.

Two goal posts stand on each goal line. The posts are 5.6 metres apart and are connected by a crossbar 3 metres above the ground.

For more information about the Rugby Union field, see the diagram in this article.

The Rugby Union ball is an inflated oval rubber bladder encased in leather. It is about 28 centimetres in length and weighs between 400 and 450 grams.

The officials. A *referee* and two *touch judges* officiate a match. The referee controls the game, and his judgment is final. The touch judges signal when and where the ball goes *into touch* (out of bounds), and they indicate whether a kick at goal is successful. They also inform the referee of any foul play.

The team consists of 15 players—8 forwards and 7 backs. The forwards attempt to win possession of the

Rugby football is a fast, rough team sport. The player carrying the ball is trying to run it down the field toward his opponents' goal line. Players can also advance the ball by kicking.

ball. The backs then advance the ball toward the goal by running, passing, or kicking. Forwards may also participate in the running, passing, and kicking activity.

Scoring. A team can score a *try,* a *conversion,* and a *goal.* A try is scored when any player touches the ball down on the ground in the opponent's in-goal area. A try counts 5 points.

After a try, a player on the scoring team attempts to *convert* the try. To convert a try, the player *place-kicks* the ball over the crossbar from a point opposite the spot where the player's team scored the try. Place-kicking involves kicking the ball from a prepared piece of turf called a "place." Defensive players stand behind their own goal line during the attempted conversion. A successful conversion scores 2 points.

There are two kinds of goals, a *penalty goal* and a *dropped goal.* Each counts 3 points. A player scores a penalty goal by place-kicking the ball over the crossbar on a *penalty kick.* A penalty kick is awarded when the opposing team infringes certain *laws* (rules of the game). A player scores a dropped goal by drop-kicking the ball over the crossbar while the ball is in play.

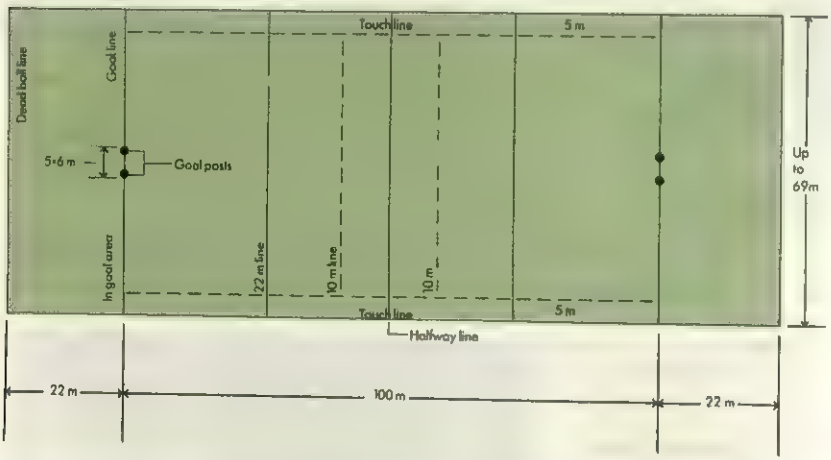
How to play Rugby Union. The kickoff starts a Rugby Union match and also starts play in the second half. A player restarts play after either team has scored by drop-kicking from the centre spot. Members of the receiving team take up positions behind the 10-metre line.

Advancing the ball. The team that secures possession of the ball tries to gain territory toward the opponents' goal line by running, passing, or kicking the ball. Players are not allowed to pass the ball *forward* (toward the opponent's goal). The ball can only be passed laterally or backwards. In addition, players cannot *knock on* (hit the ball toward the opponent's goal line with their hand or arm).

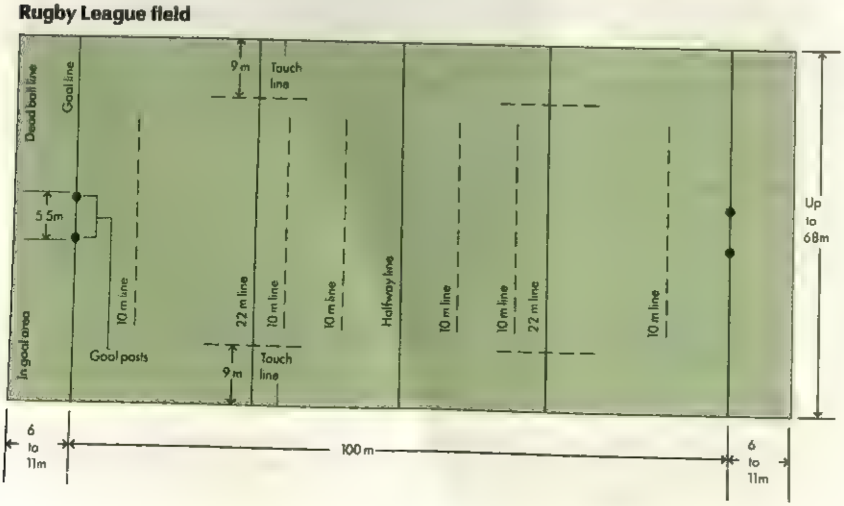
Players can tackle any opponent who is carrying the ball. The ball carrier avoids a tackle by dodging opponents or by passing the ball to a teammate. The ball carrier also may avoid a tackle by *handing off* the opponent, called a *fend.* That is, the player may push the opponent away by using the palm of the hand. However, no player can strike or punch any opponent. When a player is tackled, the player must release the ball to allow play to continue. Any player may pick up the ball and run with it or kick it.

A player may kick the ball directly over the touch line or side line only from behind his own team's 22-metre

Rugby Union field



Rugby League field



A Rugby football field consists of the field of play and the in-goal areas. The field of play is a rectangle bordered by the touch lines and the goal lines. The in-goal areas are behind each goal line and are enclosed by the goal lines and dead-ball lines. Rugby League and Rugby Union fields are about the same size, but they have some different markings. The diagram on the upper left shows a Rugby Union field. The diagram on the lower left shows a Rugby League field.

line. He can kick the ball over the touch line or side line from in front of the 22-metre line only if the ball bounces before going over the touch line or side line.

Replacements. In international matches, up to three players may leave a game only after a doctor determines that the player is not fit to continue playing. Replaced players may not reenter the match. A substitute may play for five minutes in place of an injured player. If the player cannot return within that time the substitute becomes his replacement.

The scrum. A scrum restarts play after one of the teams has committed a minor violation, such as a forward pass. In a scrum, the two opposing sets of forwards link themselves together tightly, bending forward from the waist to form a tunnellike formation. The halfback from the team not responsible for the violation "feeds" the ball into the tunnel. The two sets of forwards push from opposite sides as soon as the ball enters the scrum. Each side attempts to move the scrum into a position that allows its *hooker* to heel the ball back through his own team scrum to gain possession. The hooker is positioned in the front and centre of the front row of the forwards in the scrum.

The lineout. A lineout restarts play after the ball has gone over the side line or into touch. A player from the team not responsible for putting the ball in touch throws the ball in bounds between two opposing lines of forwards. Each set of forwards tries to outjump the other and secure possession of the ball by catching it, or by palming it to its backs.

The forwards also form a *ruck* or a *maul.* Both formations continue play without interruption after a tackle. In a ruck, the forwards close in around the ball after the ball carrier has been tackled and the ball has gone to ground. The forwards attempt to heel, or "ruck," the ball back for their backs to continue play. A maul occurs when several forwards surround the ball carrier during a tackle and the tackled player is able to remain on his feet. The opposition players in the maul attempt to wrestle the ball from the ball carrier.

Organization. Organizations called *Unions* control Rugby Union in the United Kingdom. There are separate unions for England, Ireland, Scotland, and Wales. Rugby Union players in the United Kingdom and Ireland observe the laws of the International Rugby Football Board.

The most important rugby union competition is the *five nations championship.* This championship is essentially two competitions in one. Five teams—England, Ireland, Scotland, Wales, and France—take part in the championship. Each side plays against each of the other four teams—two games at home and two away. The side that wins the most matches takes the championship. Within this contest, the four *home* international sides of England, Ireland, Scotland, and Wales compete for an imaginary prize called the *Triple Crown.*

The United Kingdom and Ireland together field a touring team of players selected from each of the four home sides. This team, popularly known as the *British Lions,* travels to many countries, notably Australia and New Zealand. Teams from those countries also visit the United Kingdom and Ireland. The *Barbarians* are a team of specially invited players who stage matches against top touring teams and club sides.

Rugby Union is the national winter game of New Zealand. More than 200,000 people play the game in New Zealand. More than 130,000 play in Australia.

A Rugby League match between teams from Australia and New Zealand creates great interest in both countries.

Australia has two interstate matches each season, played between New South Wales and Queensland. Teams from 28 provincial rugby districts in New Zealand compete in 160 first class fixtures yearly.

New Zealand also has another well-known national competition for provincial teams. It is called the *Ranfurly Shield.* The shield is known as a *challenge trophy,* and is competed for annually.

Australia and New Zealand both field national teams. The Australian team is called the *Wallabies.* The New Zealand team is called the *All Blacks,* because the players wear black jerseys, shorts, and socks. By the beginning of the 1990's, the Wallabies had reinforced their reputation as the best Rugby Union team in the world in international competition, fully deserving their victory in the 1991 Rugby World Cup.

Rugby League

Rugby League is played in Australia, France, New Zealand, Papua New Guinea and the United Kingdom. The team from the United Kingdom is known as the Great Britain team. Most of the countries that play Rugby League regularly send their national teams on overseas tours. Most touring teams play a *test series* consisting of three matches against the home team.

The field. The field is a maximum of 68 metres wide. The goal lines are 100 metres apart. An in-goal area from 6 to 11 metres extends beyond each goal line. The field is divided into 10-metre areas with a halfway line in the

A line-out restarts play in Rugby Union after the ball has gone out-of-bounds. A player tosses the ball in between two lines of forwards, and each group tries to pass the ball to its backs.

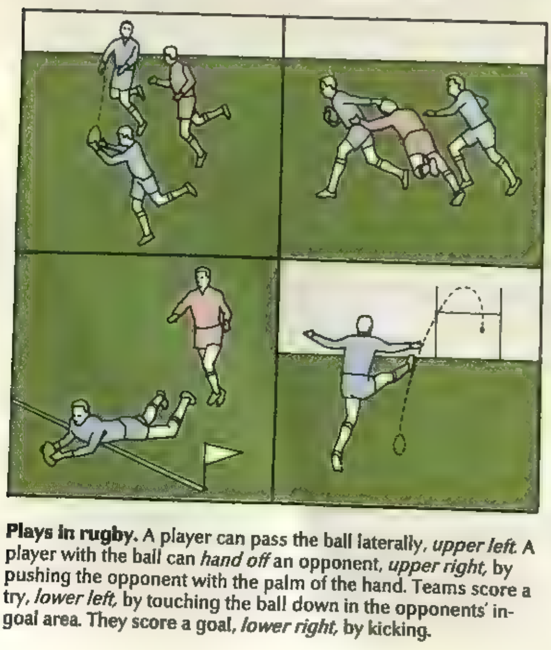
A scrum puts the ball in play in Rugby League. The ball is tossed into a tunnellike formation made by the forwards from each team. Players in the scrum try to heel it to a teammate.

middle. Two goal posts stand on each goal line. The posts are 5.5 metres apart.

For more information about the Rugby League field, see the diagram in this article.

The ball in Rugby League is an inflated rubber sac covered with leather or synthetic material. It is oval-shaped and averages about 28 centimetres long and weighs about 410 grams.

The officials. A referee and two touch judges officiate the match. The referee controls the game and his judgment is final. The touch judges assist the referee in all phases of the game. Their chief function is to signal with a flag whether the ball or ball carrier crosses the sideline. They can also inform the referee of player misconduct and indicate whether a goal has been correctly scored.



Plays in rugby. A player can pass the ball laterally, *upper left.* A player with the ball can *hand off* an opponent, *upper right,* by pushing the opponent with the palm of the hand. Teams score a try, *lower left,* by touching the ball down in the opponents' in-goal area. They score a goal, *lower right,* by kicking.

A team has 13 players—6 forwards and 7 backs. The forwards attempt to win possession of the ball. The backs advance the ball toward the goal by running, passing, or kicking.

Scoring includes a *try,* a *conversion,* a *penalty kick,* and a *field goal.* A player scores a try when he grounds the ball in the opponents' in-goal area. A try counts 4 points. To score a conversion (also called a *kick at goal*), a player from the team that scored the try kicks the ball over the crossbar between the goal posts. The player place-kicks the ball from a point opposite the spot where the try was scored. A conversion counts 2 points.

A penalty kick is taken from the spot where the other team's violation occurred. The kick is worth 2 points if the ball passes over the crossbar. The team awarded the penalty kick may choose to gain ground instead of taking the kick, by kicking the ball outside the touch lines.

A player scores a field goal by drop-kicking the ball through the goal posts and over the crossbar at any time during the game. A field goal counts 1 point.

How to play Rugby League. The kickoff starts a Rugby League match and also starts play in the second half. A player place-kicks the ball from the centre spot on the halfway line. The receiving team stands behind the 10-metre line.

Advancing the ball. The team in possession of the ball tries to move it over the opponent's goal line. Any player can run with the ball and kick it in any direction. He may pass, throw, or knock the ball to any teammate not in front of him. Only the player carrying the ball is allowed to be tackled.

Replacements. Up to four players may be substituted in a match for any reason. A replaced player cannot re-enter the game.

Playing the ball. During a game, a team in possession is allowed 6 tackles, or *downs,* to score points. If the team does not score, a *hand-over* occurs to allow the opposing team 6 tackles. After each tackle is completed, the ball carrier places the ball on the ground and *plays the ball* back with the foot to one of his teammates. That player can then pick up the ball to continue play. All

The All Blacks, New Zealand's national Rugby Union team, plays regularly against the Australian team, which is known as the *Wallabies.*

players from both teams must be 5 metres away and cannot move up until the ball is played.

The scrum. A scrum, or *scrummage,* restarts play after one of the teams has committed a minor violation or a ball carrier goes over the sideline. In a scrum, the two opposing sets of forwards link themselves together tightly and lower their heads to make a tunnellike formation. A player from the team not responsible for the violation tosses the ball into the scrum. The two sets of forwards push from opposite sides as soon as the ball enters the scrum. Each side attempts to move the scrum into a position that allows its hooker to kick the ball out of the scrum to a teammate.

Organization. Until the 1980's, Rugby League was restricted chiefly to Cumbria, Lancashire, and Yorkshire in northern England. It then expanded with the formation of teams in Wales and southern England. Most professionals in Rugby League are part-time players. Several hundred amateur Rugby League clubs play in *open age, youth,* and *school age* groups.

Great Britain plays France twice each season, at home and away. Great Britain also plays matches regularly against touring sides from Australia, New Zealand, and Papua New Guinea.

Rugby League is one of the most popular sports in Australia and New Zealand. It is played on an organized basis in all states and territories.

In the 1980's, Norfolk Island became an affiliated body of the Australian Rugby League. By the 1980's, the game had grown to such a degree in Papua New Guinea that the country was included in international competition, playing tests against all participating nations.

In New Zealand, Auckland is the stronghold of Rugby League. The game is also popular in Canterbury. In the 1980's, large increases in the number of players and the number of spectators occurred in Wellington and the upper half of the North Island.

The New Zealand national team is called the *Kiwis.* Players wear black jerseys with two white V's, black shorts, and black socks with two white hoops at the top. The Australian team is called the *Kangaroos.* Players wear green jerseys with two gold V's, green shorts with a gold stripe, and green socks with gold hoops. The national team of Papua New Guinea is known as the *Kumuls.* They wear orange shirts with black V's, black shorts, and orange socks with black hoops.

The Australian Rugby Football League Limited governs the game in Australia. Its equivalent in New Zealand is the New Zealand Rugby Football League (Inc.). The overseer in Papua New Guinea is the Papua New Guinea Rugby Football League.

History

According to tradition, Rugby football originated from a football game played at Rugby School in Rugby, England, in 1823. During the game, a student named William Webb Ellis broke the rules by catching the ball and running with it. Players of the new game adopted use of an oval-shaped ball to make passing and carrying easier.

Rugby football quickly became popular throughout the United Kingdom (UK). Teams could play with an unlimited number of players at one time, and there were few rules. Early Rugby Union teams had as many as 20 players. But in the university match of 1875, both Oxford and Cambridge fielded teams of 15 players each. In 1871, a conference of Rugby clubs formed the English Rugby Union, made up of 21 amateur clubs. The conference set the number of players on a team at 15 and established other general rules. Scotland formed its Rugby Union in 1873, and Ireland organized a Rugby Union in 1874. The Welsh Rugby Union formed in 1881.

In 1895, 21 teams from the north of England broke from the Rugby Union to form the Northern Rugby Union. These northern clubs wanted to pay their players, in order to compensate them for the money they lost through taking time off work to play rugby. The Rugby Union did not allow this as they felt it would mean the end of amateurism. The northern clubs changed their name to the Rugby Football League in

Twickenham, London, is one of the grounds used for Rugby Union international matches.

1922. The International Rugby Board was formed in 1948 to govern Rugby League internationally.

Australia. The New South Wales Rugby Union was formed in 1875. It is the oldest union outside the UK. In 1907, Rugby League was formed. It took some star players and many supporters from Rugby Union, and soon became the more popular of the two games. Since 1930, rugby has become increasingly popular. The Wallabies rank among the world's top rugby union sides.

New Zealand. British settlers introduced the game into New Zealand in about 1870. Bitter fighting between the Maori and the European settlers had only recently ended. The Maori found a new outlet for their energies, and accepted the game as if they had known it all their lives. Some of the greatest rugby players have been Maori. Rugby League began in New Zealand in 1905.

New Zealand rugby teams have exchanged visits with Australian sides regularly since 1882. Only World Wars I and II have interrupted these exchanges.

Outline

I. Rugby Union
- A. The field and equipment
- B. The officials
- C. The team
- D. Scoring
- E. How to play Rugby Union
- F. Organization

II. Rugby League
- A. The field
- B. The officials
- C. A team
- D. Scoring
- E. How to play Rugby League
- F. Organization

III. History

Questions

What protective equipment may be worn by rugby players?
Which teams take part in the Rugby Union five nations championship?
How is a *try* scored in Rugby football?
What is a *scrum*?
What is a *lineout* in Rugby Union?
Why is the New Zealand team called the All Blacks?
How many tackles is the team in possession allowed in Rugby League?
How did rugby football first break the rules of a football game? What year did it happen?
Why did clubs in northern England break from the Rugby Union?
When did the Maori begin to play rugby?

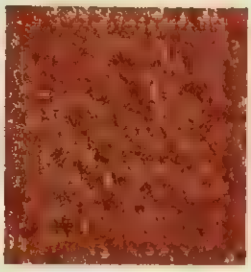
Rugby School is a famous English independent school founded in 1567 at Rugby, England. Rugby's playground was one of the founding places of Rugby football. The school became one of the leading independent schools in England under Thomas Arnold, who served

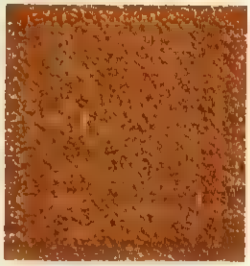
Rugs and carpets are made by machine or by hand. Most such floor coverings are *tufted.* In the tufting process, *left,* a machine inserts loops of yarn through a backing. Handmade Oriental rugs, *right,* are valued for their rareness and beauty.

Kinds of rugs and carpets Rugs and carpets are classified according to the texture of their top surface, called the *pile*. An example of each of the eight main types of rugs and carpets is shown below.


Level loop


Buried end

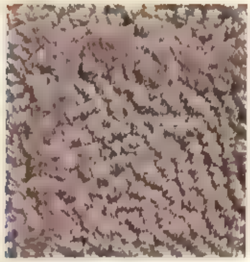

Shag


Velvet


Saxony


Frieze


Cut and loop


Tip sheared

as headmaster from 1828 to 1842. Arnold is the popular headmaster who appears in the novel *Tom Brown's School Days*, by Thomas Hughes. Rugby's average enrolment is more than 750. Girls were accepted in the school for the first time in 1993.

Rugs and carpets are fabrics used as floor coverings. They add beauty, comfort, and warmth to a room, and they help absorb sound. A rug covers only part of the floor of a room and is not fastened down. A carpet covers an entire floor and is nailed or tacked down.

Most rugs and carpets are mass-produced and are made in a variety of textures and patterns. Some rugs are made in standard sizes. Other rugs are cut from large rolls of carpeting. Most carpeting is produced in 3.7-metre widths, but some is 5 metres wide. Other carpeting is cut into 23-, 30-, or 46-centimetre squares. Carpeting made on a machine more than 1.8 metres wide is called *broadloom carpeting*. Rugs may also be made by hand. Handmade Oriental rugs are particularly valued for their rareness and beauty.

Materials used in rugs and carpets

Rugs and carpets have two main parts, the *pile*, or *face*, and the *backing*. The pile is the top surface, and the backing is the undersurface. Various manufactured or natural fibres are used in making both the pile and the backing.

The chief manufactured fibres used in pile are nylon, polyester, acrylic, and olefin. Nylon resists soiling and reduces the amount of static electricity that might be given off by the floor covering. Polyester can be dyed in brighter colours and it provides lustre and durability. Acrylic produces bulky, lightweight rugs and carpets that resist sunlight and give off little electricity. Olefin floor coverings are widely used because they are strong and they resist moisture.

Wool is the main natural fibre used in making pile. Wool floor coverings are attractive, soft, and durable. Many people consider them the finest made. But most wool floor coverings cost more than those produced from manufactured fibres.

The backing of most rugs and carpets is made of olefin or of jute, a natural fibre. Linen, rayon, and cotton are also used.

Kinds of rugs and carpets

Rugs and carpets are classified according to their pile textures. There are eight main kinds of rugs and carpets:

Level loop rugs and carpets have a smooth, tight texture. All the loops of yarn that make up the pile have the same height.

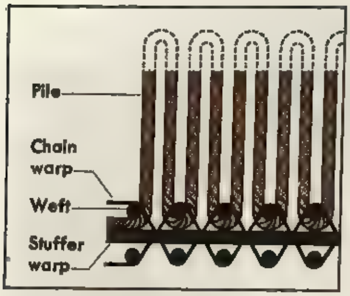
Buried end rugs and carpets have an uneven texture. The loops of their pile vary in height, giving the surface a patterned effect.

Shag rugs and carpets have a rough texture. The cut ends of their yarns are longer—and thus create a higher pile—than those of the other types of cut pile floor coverings. The yarns lie at random in all directions, creating a casual, shaggy effect.

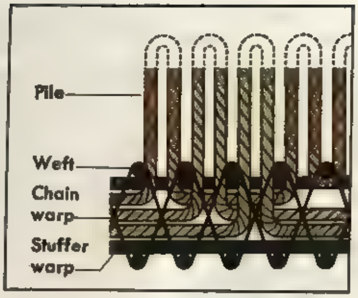
Velvet rugs and carpets are soft and have a luxurious appearance. They are thicker and have shorter pile yarns than do shag carpets.

Saxony rugs and carpets resemble the plush type. However, each yarn of a saxony floor covering stands erect and can be seen from the surface. The fibres in the yarns of a velvet rug or carpet blend together.

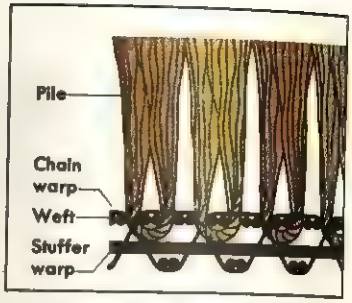
Frieze rugs and carpets have a rougher texture than the other members of the cut pile group. The yarns of a



A velvet weave is the simplest type. Almost all the pile yarn appears on the surface of the floor covering.



A Wilton weave has all its yarns running in rows along the backing, but only one colour is raised to the surface at a time.



An Axminster weave has each pile yarn inserted independently. Most of the pile yarn appears on the surface.

frieze pile are tightly twisted, and they curl when inserted into the surface.

Cut and loop rugs and carpets have yarns that vary in height. The longer yarns provide a cut pile. The shorter yarns are looped and may be hidden by the longer ones. Therefore, the surface of a cut and loop floor covering may resemble that of a shag type.

Tip sheared rugs and carpets have a patterned surface. The pile at first consists of loops of various heights, but some of the loops are then sheared. In most cases, only the longer loops are cut. However, some of the long loops may be sheared, and others may remain looped.

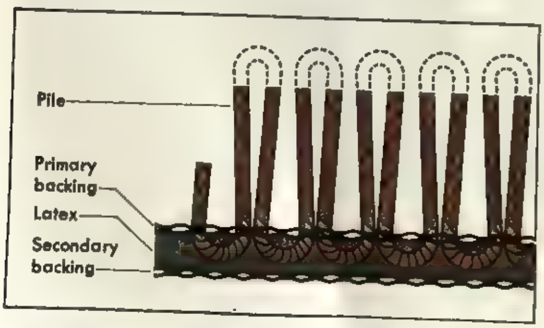
How rugs and carpets are made

Most rugs and carpets are made by a process called *tufting*. The rest are made by *weaving* or other methods.

Tufting is the fastest and cheapest method now used to make rugs and carpets. Tufted floor coverings consist of pile yarns called *tufts*, which are inserted into the backing.

A tufting machine has hundreds of needles set in a row on a device called a *needle bar*. When the needle bar is lowered, each needle forces a loop of yarn through a layer of backing called *primary backing*. The loops form a row of tufts. As the needle bar is lifted, devices called *loopers* hold the tufts in place under the primary backing, forming a looped pile. A cut pile can be made by simply attaching a knife blade to each looper.

Latex is applied to the primary backing to secure the tufts. A layer of backing called *secondary backing* may be placed over the latex to provide extra durability. The secondary backing is made of jute or synthetic materials. Some tufted floor coverings have a layer of latex foam instead of a secondary backing which makes the surface seem softer.



A tufted floor covering consists of pile yarns called *tufts*, which are forced through a backing by needles.

Weaving was the chief method of manufacturing rugs and carpets until the development of tufting in the 1950's. Woven floor coverings, which are produced on looms, are made by interlacing the pile yarns with backing yarns. Weaving the two kinds of yarns together holds the pile yarns securely in the backing.

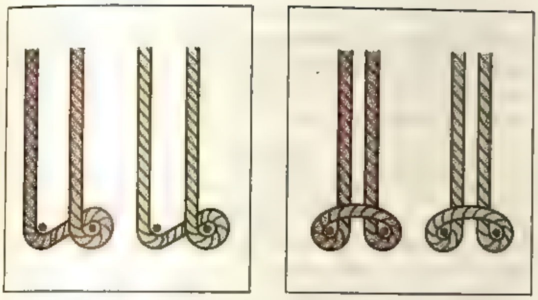
The pile of a woven rug or carpet is formed from one set of yarns. The backing is made from two sets. The pile yarns are woven into the backing in rows. During the weaving process, these yarns form loops over long, flat pieces of metal called *wires* that lie across the loom. This action creates a looped pile. A cut pile is produced by wires that have a knife blade at one end. In the backing, one set of yarns, called the *weft*, runs crosswise on the loom. Another set, called the *warp*, runs lengthwise. There are two kinds of warp yarns, *chains* and *stuffers*. Chain warps cross over and under the weft yarns to form the weave. Stuffer warps are extra yarns that run through the backing to give it greater bulk and strength.

There are three chief types of woven rugs and carpets: (1) velvet, (2) Wilton, and (3) Axminster. They differ in the way their pile yarns are woven into the backing, and each type is made on a different kind of loom. The backing for the three types is made in basically the same way.

Velvet rugs and carpets are made with the simplest type of weave. They are woven on looms similar to those used in making regular cloth. The majority of velvet floor coverings have a pile of one colour, and a design cannot be woven into the surface. Most of the pile yarn is on the surface of the rug or carpet.

Wilton rugs and carpets are woven on a loom that has a special device called a *Jacquard mechanism*. With this device, as many as six different coloured yarns may be used in each row of the pile. A design, if desired, may be created on the surface. All the yarns run in rows along the backing, but only one yarn is raised to the surface at a time. Thus, a yarn of the desired colour appears in the proper place in the design. The other yarns are buried under the surface, where they give strength and springiness to the backing.

Axminster rugs and carpets may be produced in an unlimited number of colours and patterns. Most of the



Knots for Oriental rugs may be made in one of two ways. A *Persian*, or *Sehna, knot, left,* twists the pile and warp yarns together. A *Turkish*, or *Ghiordes, knot, right,* ties them together.

pile yarns of an Axminster floor covering appear on the surface. Each pile yarn is inserted into the carpet independently. As each yarn is inserted, it is interwoven with the backing yarns.

Other methods include *knitting, needle-punching, braiding, embroidering,* and *hooking.*

Knitted rugs and carpets are produced on knitting machines by a process similar to hand knitting. The pile yarns and the backing yarns are knitted together. Needle-punched floor coverings are made from fibres that have been tangled together by means of barbed needles. Some fabrics formed by needle-punching are used both indoors and outdoors.

Braided floor coverings are manufactured from individual braids of yarn or fabric. The braids are sewn together and coiled into a circle, an oval, or some other shape. Embroidered floor coverings are created by stitching designs onto the backing. The designs form the pile. Hooked rugs are produced by punching yarns through the backing with a metal hook.

Oriental rugs

People who live in the Orient have traditionally created beautiful handmade rugs. Authentic Oriental rugs have pile yarns that are hand-knotted onto a woven backing. These rugs are made in such countries as China, India, Iran, and Turkey.

Handmade oriental rugs are considered to be of great value because they have intricate designs and they also take a long time to weave. The value of an Oriental rug depends on the size and closeness of the weave. Tightly woven rugs cost the most because they have the greatest durability.

An Oriental rug is not as perfect as a mass-produced rug. The size and shape may not be exact, and the colour in various areas may differ slightly. Such characteristics, rather than being considered imperfections, are regarded as evidence that a rug is an Oriental.

Oriental rugs are woven on simple looms. A small rug may be woven by one person, but most large Oriental rugs are made by several weavers. First, the rug makers knot a row of pile yarns to the warp yarns. Next, they weave two weft yarns through the warp. The knots and weft yarns are then packed down tightly on the previously woven rows with a comblike device. After several rows have been knotted, the workers cut the ends of the pile yarns to create an even rug surface. The knotting process is then repeated.

Detail of a wool rug (early 1800's)

Detail of a silk rug (1500's) of the Safavid period

Oriental rugs include Caucasian rugs, *left,* and Persian rugs, *right.* Caucasian rugs are made in areas of the Caucasus Mountains, which lie between Europe and Asia. They have bold geometric designs. Persian rugs come from Iran (formerly Persia). They are characterized by graceful patterns.

Genesis by Helen Webber

A handmade rug used as a wallhanging, *above,* adds a modern decorative touch to a home or office.

Every Oriental rug is made with one of two types of knots. A *Persian,* or *Sehna, knot* twists the pile and warp yarns together. A *Turkish,* or *Ghiordes, knot* ties the yarns together. Most Oriental rugs have from 8 to 78 knots per square centimetre.

Most Oriental rugs have wool pile yarns, but some have pile yarns of silk. The warp yarns for Oriental rugs are made of camel hair, cotton, linen, silk, or wool. Most of the weft yarns are made of cotton.

The chief colours in most Oriental rugs are blue, brown, red, and white. The yarns are treated with chemical dyes to obtain various shades of these colours. Before these chemical dyes were developed, the yarns were coloured with dyes that were made from plants and minerals.

Oriental rugs called *prayer rugs* are made in Islamic regions of Asia. The design of a prayer rug includes an arrow or some pointed shape that indicates the head and foot of the rug. Muslims face Mecca, their holy city, as they kneel in prayer, and the rug is placed with the design pointed toward it.

There are six chief types of Oriental rugs: (1) Caucasian rugs, (2) Chinese rugs, (3) Indian rugs, (4) Persian rugs, (5) Turkish rugs, and (6) Turkoman rugs. They are named after the regions where they are made.

Caucasian rugs come from areas of the Caucasus Mountains, which lie between Europe and Asia. These rugs have bold geometric designs and are coloured primarily blue and red.

Chinese rugs have designs that feature philosophical and religious symbols of China. The designs are woven into backgrounds of blue, red, and yellow.

Indian rugs resemble Persian rugs in colour and pattern. But the designs are mostly geometric.

Persian rugs are made in Iran (formerly Persia). They are characterized by graceful patterns that feature flowers, leaves, and birds. Persian rugs have soft colours that blend together.

Turkish rugs are known for their rectangular patterns and their floral designs arranged in rows. Most of these rugs have large areas of solid colours.

Turkoman rugs come from Turkestan, a region of central Asia. They are woven in soft colours and have simple geometric designs.

History

Some prehistoric people may have used animal skins as floor coverings in their caves or huts. After people learned to weave, they made floor mats from grasses and other plant material.

No one knows when rug making began. People in Turkestan wove rugs without pile about 5000 B.C. The earliest known fabric made with pile is called the *Pazyryk rug.* It was made about 425 B.C. and was discovered in a tomb in southern Siberia.

Crusaders who travelled from Western Europe to the Middle East during the A.D. 1100's and 1200's took rugs back to Europe. In the 1200's, Spain became the first European country to produce rugs. England started making pile rugs in the 1500's. In the 1600's, France began to make a style of rug called the *Savonnerie,* which had a deep pile. In the 1700's, England was the centre of the European rug and carpet industry. An English inventor named Edmund Cartwright developed the power loom in the 1780's.

In North America, the most common rugs were braided rugs, hooked rugs, and *rag rugs,* which were made from scraps of cloth. The first U.S. carpet mill was established in 1791 in Philadelphia.

The Jacquard mechanism was invented about 1800 by Joseph M. Jacquard, a French weaver. In 1841, Erastus B. Bigelow, an American inventor, perfected a power loom for making carpets. A loom for producing Axminster carpets was patented in 1856.

The tufting machine was introduced in the early 1950's. By the mid-1950's, more tufted rugs and carpets than woven ones were being produced.

Related articles in *World Book* include:

Asia (picture: Skilled craftworkers)
Carpet beetle
Cartwright, Edmund
Indian, American (picture: The Navajo)
Industry (pictures: In a developing nation; In a developed nation)
Interior decoration (Choosing patterns and textures)
Iran (picture)
Islamic art (picture)
Jacquard, Joseph M.
Tapestry
Turkestan (picture)
Weaving

Ruhr is a coal-mining and industrial region in Germany. It lies in the western part of the country. Several branches of the Rhine River run through the region, including the Ruhr River, from which it takes its name. The area most commonly known as the Ruhr is rectangular in shape, with corners roughly at Hamm, Lüdenscheid, Mönchen-Gladbach, and Wesel. The Ruhr covers about 7,330 square kilometres. People sometimes refer to a greater Ruhr area, which includes the Cologne and Bonn regions to the south.

The people and their work. The Ruhr is one of the most crowded sections of Europe. It has a population of about 8,500,000, excluding the Cologne and Bonn areas. Dortmund, Duisburg, Düsseldorf, Essen, and Wuppertal are large industrial cities in this region. The entire area along the Ruhr River from Duisburg to Dortmund forms practically one continuous city.

The Ruhr includes one of the largest concentrations of industry in the world. It has great coal fields and a great transportation network that includes railways and river and canal developments. The region's industries produce chemicals, iron and steel, and textiles.

History. The Ruhr became important to German industry in the mid-1800's. Its huge coal fields and fine transportation facilities made it important as a coal-mining area. In 1871, Germany won control of almost all of Alsace and part of Lorraine after the Franco-Prussian War. This made iron ore from Lorraine available to German industries without customs duties. Industrialists in the Ruhr area began to bring in ore from Lorraine, and the region developed into an industrial centre.

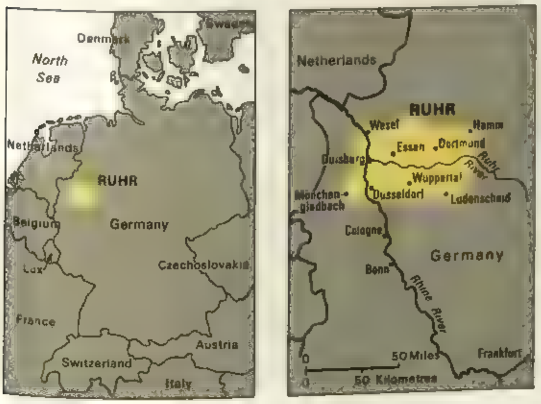
Germany lost Lorraine back to France after World War I. For a time it seemed likely that the Ruhr would again become only a mining district. But the German government paid huge sums to iron manufacturers for the loss of Lorraine. With this money, the industrialists built smelting works that could process iron ore from Sweden.

By 1922, Germany had fallen behind in paying France and Belgium for damages caused during World War I. French and Belgian troops occupied the Ruhr in January 1923 to force Germany to make its payments. But the German government encouraged Ruhr workers to follow a policy of passive resistance and to produce as little as possible during the occupation.

The French took harsh steps to increase German production. But all their measures failed. The decrease in production of the Ruhr soon affected the economic life of France and Germany disastrously. Both countries headed toward national bankruptcy.

On Sept. 27, 1923, Germany finally ended its passive resistance in the Ruhr. At the same time, France saw that it was useless to occupy the Ruhr any longer. Under the terms of the Dawes Plan, French and Belgian troops left the region by Aug. 1, 1925.

Adolf Hitler came to power in Germany in 1933. He used Ruhr industries to supply the Nazi war machine. During World War II (1939-1945), Allied bombers made many devastating raids on the Ruhr. American armies finally captured the Ruhr, and British troops occupied the area.



The Ruhr is a region in western Germany.

Ruhr River rises in Westphalia, Germany, and flows 232 kilometres through the famous Ruhr Valley. It joins the Rhine River near Duisburg. See **Ruhr.**

Another Ruhr (Roer) River rises on the Belgian frontier and flows northward through Germany for 108 kilometres. It enters the Maas (Meuse) River at Roermond, the Netherlands.

Ruisdael, Jacob van (1628?-1682), was the greatest Dutch landscape painter of his time. His name is also spelled *Ruysdael.* Other artists of Ruisdael's time stressed the placid character of the Dutch countryside, but Ruisdael depicted nature as filled with drama and mood. He painted stormy seas, rushing waterfalls, melancholy ruins, dark forests, and clouded skies pierced by rays of light. Romantic painters of the 1800's admired his poetic approach to nature and often imitated his style and subject matter.

Jacob van Ruisdael's painting, *The Mill at Wijk,* completed in about 1665, shows the painter's dramatic interpretation of the Dutch countryside.

Ruisdael was born in Haarlem and in 1648 became a member of the painters' guild there. His *View of Haarlem* is reproduced in the **Painting** article. In 1656, he moved to Amsterdam, where he produced his finest paintings. In Amsterdam, he expanded his range of subjects to include urban scenes.

Ruiz, Juan (1283?-1350?), ranks among Spain's important poets on the strength of a single known work. His *Book of Good Love* (*Libro de buen amor,* 1330-1347), a collection of stories in verse and song, is the most entertaining and human book in medieval Spanish literature. "Good love" in the title stands for love of God and the Virgin Mary, a popular topic in medieval Spain. However, the work is more a praise of human love than spiritual love. See **Spanish literature** (Early medieval literature).

Ruiz was born in Alcalá de Henares and was archpriest of Hita, a small town in Castile. He probably suffered a long prison term by order of the Archbishop of Toledo. Ruiz' *Book of Good Love* mingles mock allegories, tales from medieval French literature, and references to classical authors with realistic episodes apparently based on his own travels and amorous adventures.

Ruiz, Saint Lorenzo (1600?-1637?), was the first Filipino to be declared a saint by the Roman Catholic Church. In about 1637 he was executed in Japan with a group of Christian missionaries. He was declared a saint in 1987.

Lorenzo Ruiz was part-Chinese. In 1636, he fled from the Philippines to escape a criminal charge, of which no detailed record has survived. Leaving behind his wife and children, he joined a group of Dominican missionaries and went to Japan. At that time, Japanese rulers wanted to stop the Christian movement.

When the missionaries reached Okinawa, they were jailed for a year. They were then taken for trial at Edo (now Tokyo). When asked if he would *recant* (give up his beliefs), Lorenzo replied that he "would rather die a thousand deaths than renounce" his Christian faith. Lorenzo and his companions were buried alive head down.

Ruiz Cortines, Adolfo (1891-1973), served as president of Mexico from 1952 to 1958. A civil servant for 30 years, he was governor of Veracruz from 1944 to 1948 and secretary of the interior under President Miguel Alemán.

As president, Ruiz Cortines fought dishonesty and corruption in reforming the civil service. He also consolidated gains made by Alemán's administration in developing agriculture and industry. In 1954, Ruiz Cortines helped make it easier for Mexicans to cross the border for seasonal agricultural work in the United States. He directed reform of the government of Mexico City, and effectively met the crisis caused by an earthquake in 1957. Ruiz Cortines introduced electoral reforms, and women were able to vote for the first time in 1958.

Adolfo Ruiz Cortines

Ruiz Cortines was born in Veracruz.

Rum. See **Alcoholic beverage** (Rum).

Rum Hospital is the popular name in Australia for the extensive group of buildings on the eastern side of Macquarie Street, Sydney, which replaced the original colonial hospital near Sydney Cove.

Governor Lachlan Macquarie was eager to provide Sydney with a much-needed hospital. In 1810, he granted the contractors a limited monopoly to import and sell rum in return for building the hospital. Rum was used as a form of money in the early colony. The government's contribution was limited to oxen, draught bullocks, and convict labourers.

The hospital opened in 1816, and was the most imposing structure in Sydney at that time. The central block was demolished in 1879 to make way for the present Sydney Hospital. The north and south wings, which

Rum Hospital was one of the most imposing buildings in Sydney when it was drawn by F. C. Terry in the 1850's. The central block was demolished in 1879 but the other two blocks still stand.

were originally surgeons' barracks, are still standing. The north wing forms part of State Parliament House. The south wing once housed the Sydney branch of the Royal Mint.

Rum Jungle is a uranium-mining centre in the Northern Territory, Australia, about 97 kilometres south of Darwin. For location, see **Northern Territory** (map). A prospector, John Michael White, first discovered uranium at Rum Jungle in 1949. In 1952, a joint British-American purchasing agency agreed to provide funds to develop the deposits. In 1954, a private company began open-cast mining on behalf of the Australian government. It also built an extraction plant to treat the uranium ore. Rum Jungle yielded more than 1,524 tons of uranium oxide before the government contract with the purchasing agency expired in 1963. Mining then stopped, but treatment of ore continued until 1971. The name may have come from earlier rum-drinking gold prospectors.

Rum Rebellion is the name usually given to events that took place in Sydney on Jan. 26, 1808, when the New South Wales Corps illegally arrested and deposed Governor William Bligh. The name *Rum Rebellion* was coined in 1938, when it was used as the title of a book by H. V. Evatt, who later led the Australian Labor Party. Although catchy, the name is misleading because the downfall of Governor Bligh was more complex than the book's title suggests.

Captain William Bligh, an experienced naval officer, was 51 when he arrived in Sydney, in August 1806, to govern New South Wales. A bad-tempered man with an abusive tongue, Bligh had been the central figure in the notorious *Bounty* mutiny years before. See **Bligh, William.**

The colony of New South Wales was beset with problems when Bligh took office. Shortage of coins prevented farmers from selling their crops for money. Instead, they had to barter their grain for other commodities, including rum. Many of the military officers were rum traders, making enormous profits from dealing in liquor. To help the farmers, Bligh issued an order prohibiting this sort of trading in spirits.

Unfortunately, Bligh's actions and his violent temper soon brought him into conflict with some of the colony's leading citizens. These men included the wealthy Blaxland brothers; the Townson brothers; Simeon Lord, a former convict who had become a wealthy businessman; and the entire New South Wales Corps, which Bligh wanted removed from the colony. The governor's most formidable opponent was a former officer of the corps, John Macarthur. This wealthy, powerful man was just as arrogant and quarrelsome as Bligh. Both men soon got onto a collision course that was to end in violence. See **Macarthur, John.**

In December 1807, Macarthur was arrested on a number of charges. The court appointed to try him comprised six officers of the New South Wales Corps under Judge Advocate Richard Atkins. Atkins was not a lawyer. He was a personal enemy of Macarthur, and also owed him money. The charges were written in extravagant lan-

Rum Rebellion involved Governor William Bligh. A contemporary picture showed him hiding under his bed when soldiers came to arrest him. Bligh denied that he had tried to hide.

guage, describing Macarthur as "a malicious and seditious man, of depraved mind and wicked and diabolical disposition."

Macarthur objected to being tried by a man who owed him money. As a result, the military officers refused to sit with Atkins, who stormed out of the courtroom. Macarthur was returned to the Sydney gaol. Governor Bligh immediately ordered the six officers to appear before him the next day, Jan. 26, 1808, and sent a message to the acting commander of the New South Wales Corps, Major George Johnston, stating that he intended to charge the officers with treason. This threat brought Johnston hurrying to Sydney, where he saw groups of excited people in the streets.

"Everything denoted terror and consternation," Johnston reported later. Johnston used his authority as lieutenant governor to release Macarthur from prison. Macarthur promptly drew up a petition, urging Johnston to arrest the governor and assume command of the colony. The petition found many supporters among the people Johnston described as "the respectable inhabitants, except those who were immediately connected with Governor Bligh."

Just before sunset on Jan. 26, 1808—the 20th anniversary of the colony's foundation—Johnston led his soldiers, with drums beating, toward Government House, in Sydney. Bligh observed their approach from a window. He must have guessed that they planned to arrest him, because Johnston had sent the governor a letter stating that he was "unfit to exercise the supreme authority another moment." Bligh's daughter, Mary Putland, attempted to bar the soldiers' way, but they nevertheless entered Government House and began searching for Bligh. His captors claimed that he was found hiding under a bed, but Bligh denied it. That night, people held illuminations and bonfires in Sydney to celebrate Bligh's downfall.

The lone casualty of this rebellion was a Lieutenant Laycock. While searching for Bligh in a loft, Laycock fell through a hole and was injured.

Following Bligh's arrest, the colony's affairs were administered by officers of the New South Wales Corps. Bligh remained a virtual prisoner under military guard at Government House for more than a year. Later, he agreed to return to England, and boarded the *Porpoise*.

Instead, he sailed to Hobart, hoping to enlist the support of Lieutenant Governor David Collins. But Collins proved unwilling to help him. Bligh remained aboard the *Porpoise* as a brooding and embittered outcast until his successor, Colonel Lachlan Macquarie, arrived in Sydney.

Because Bligh was at Hobart when he landed in Sydney, Macquarie was unable to fulfil the British government's instruction to reinstate the deposed governor for one day. Then Bligh returned to Sydney to collect evidence against those who deposed him. Macquarie was greatly relieved when Bligh finally sailed for England in May 1810. Macquarie described Bligh as "a most disagreeable person to have any dealings, or public business to transact with." Soon after taking office, Macquarie sent the officers of the New South Wales Corps back to England.

Johnston was court-martialled in England. He was found guilty of mutiny and dismissed from the army, though the court conceded that he had been obliged to face extraordinary circumstances. He returned to Sydney and lived on his farm at Annandale, respected by all who knew him. Macarthur went to England to give evidence, and although no action was taken against him, he had to remain in exile until 1817. Bligh, the centre of the storm, was promoted to rear admiral, but was never again entrusted with a naval command or public office.

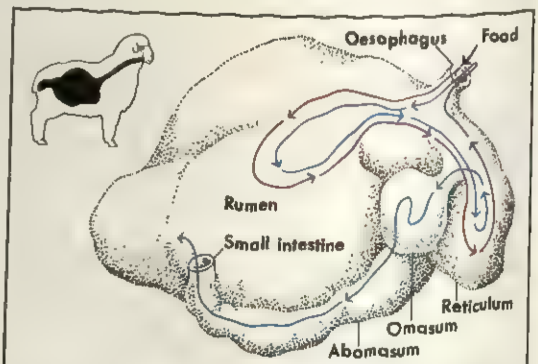
Rumania. See Romania.

Rumba, also spelled *rhumba,* is a Latin ballroom dance that originated in Africa and achieved its modern form in Cuba. Couples perform the rumba in $\frac{4}{4}$ time with a quick-quick-slow rhythm. The rumba emphasizes a swaying hip motion that is achieved by taking small steps with the knees relaxed. Steps are typically performed in a square pattern. The rumba is most often accompanied by music with a repeated beat played on percussion instruments.

A version of the rumba was first introduced into the United States from Cuba about 1914. However, the dance's exaggerated hip movements were considered too sexually suggestive and the dance did not gain acceptance. A more refined version was introduced about 1930. The dance maintained its popularity in the 1930's and 1940's, especially in England, where ballroom dance teachers standardized the figures and step rhythms.

Ruminant is the name given to a grazing animal that chews its cud and has split hoofs. Such animals as the ox, sheep, cow, camel, llama, deer, goat, antelope, and giraffe are ruminants. The ruminant has an odd way of digesting food. It swallows its food, usually grass, after chewing it only slightly. The food then goes down the animal's *oesophagus* (food pipe) and into the stomach.

Except for camels and some others, most ruminants have a stomach that has four separate *cavities* (compartments). Each cavity helps digest food. The first cavity is called the *rumen,* or *paunch.* Most of the food collects there after being swallowed. Some food passes directly into the second cavity, called the *reticulum.* The reticulum has tiny pockets in its walls that look like a honeycomb. Food stored in the rumen passes into the reticulum, where it is softened and formed into soft masses called *cuds.* As the animal rests, the muscles of the retic-



Most ruminants have a stomach with four compartments: the *rumen, reticulum, omasum,* and *abomasum.* These drawings show a sheep's stomach. Food enters the rumen and reticulum, *red arrows,* and is then rechewed as cud. Cud eventually passes into the omasum and abomasum, *blue arrows.*

ulum send the food back to the mouth to be chewed and mixed with saliva. The animal chews with a roundish motion of the jaw and swallows again. The cud passes through the rumen and reticulum to the third cavity, the *omasum,* and finally into the fourth cavity, the *abomasum.* In the abomasum, the food mixes with the stomach juice. From the stomach, the food passes into the intestine, where digestion is completed. The digested food is absorbed through the lining of the intestine and passes to all parts of the body through the bloodstream.

The ruminant chews its food with its molars. It does not have any biting teeth, or incisors, in the upper jaw. The lower teeth bite against the hard upper gum.

Scientific classification. Ruminants are in the class Mammalia. They are in the order Artiodactyla, and make up the suborder Ruminantia.

Rump Parliament was a name given to the English Parliament during the civil war that took place in the middle 1600's. It had less than a fourth of the usual number of members. The other members had been excluded from Parliament by troops of the Puritan leader Oliver Cromwell.

Civil war broke out in 1642 between the forces of King Charles I and those of the *Long Parliament* (see **Long Parliament**). Later, members of Parliament disagreed on the conduct of the war. On Dec. 6, 1648, soldiers led by Colonel Thomas Pride surrounded the House of Commons. They arrested 47 members of Parliament who opposed the trial of the king, and excluded many others. This action was called *Pride's Purge.* The remaining members became known as the *Rump Parliament,* because they were the *rump* (end) of the larger body. They brought about the execution of Charles I in 1649.

The Rump Parliament fought later against many demands made by Cromwell's army. Cromwell entered Parliament in 1653 at the head of a troop of soldiers, and ordered it dissolved. The Rump Parliament met twice after Cromwell's death. In 1660, after the members expelled by Colonel Pride had been recalled, the Long Parliament dissolved itself and ordered the election of a new Parliament.

See also **Charles (I) of England; Cromwell, Oliver.**

Runcie, Robert (1921-), was archbishop of Canterbury, in England, from January 1980 to 1991. He was born in Liverpool of Scottish parents and attended a local council school in Crosby. He won a scholarship to Oxford. During World War II, he served with the Scots Guards. In 1945, he won the Military Cross.

After graduating from Oxford, Runcie studied theology at Westcott House, Cambridge. He became a deacon in 1950 and a priest in 1951. Runcie became curate at Gosforth, Tyne and Wear. He later held academic positions, including the post of principal of Cuddesdon Theological College from 1960 to 1969. From 1970 to 1980, Runcie was bishop of St. Albans. Runcie won a high reputation for his work as Anglican chairman of the Anglican-Orthodox Joint Doctrinal Commission. He also became a broadcaster. He was the first archbishop of Canterbury to be directly appointed by the Church of England Crown Appointments Commission.

Robert Runcie

Runcie is now a life peer and retains his seat in the House of Lords after his retirement as archbishop of Canterbury.

Runcorn. See **Cheshire; New towns.**

Rundle Oil Shale Project is a plan to mine a deposit of oil shale located on the east coast of Queensland, Australia, about 30 kilometres northwest of Gladstone. The deposit contains about 5,000 million metric tons of oil shale. In an area of 15 square kilometres, five seams of oil shale have been found at depths ranging from 15 metres to 350 metres below the surface.

The existence of oil shale was revealed by dredges in the 1800's, when the 300-metre-wide sea channel between Rundle and Curtis Island was being deepened. During World War II (1939-1945), when a fuel shortage prompted some shale oil extraction in Australia, the Queensland Mines Department surveyed the Rundle district. Engineers drilled 15 holes over a 3,100-hectare area and estimated that the deposits contained 630 million metric tons of oil shale. In 1969, a mining company drilled nine more holes. But the low price of crude oil at that time made it uneconomical to mine the shale and extract the oil.

In 1973, when oil prices began to rise, the present companies began their exploration programme. They discovered that the deposit contained more than seven times the previously estimated amount of oil shale. The companies originally thought that the deposit could be mined by open-cast methods, and planned to develop the deposit in two stages.

The first stage was to produce about 3,000 to 4,000 kilolitres of shale oil per day from about 40,000 metric tons of oil shale. This stage would have been used to assess mining retorting methods. Using these results, the companies then expected that output would be rapidly scaled up to production of 30,000 to 40,000 kilolitres a day, which was equivalent to about half of Australia's crude oil production in the early 1980's.

But in 1981, the investors decided not to proceed with the original plan because of uncertainties about being able to mine the oil shale by open-cast methods. There were also inconsistent results of retorting tests carried out on Rundle oil shale in overseas plants and rapidly escalating estimates of capital costs.

Feasibility studies were expected to continue into the late 1980's, and if a decision were to be made to go ahead, commercial shale oil production was not expected to take place before the mid-1990's. It was estimated that production would probably be less than 10,000 kilolitres a day. About 250,000 metric tons of oil shale and barren rock would have to be mined daily to provide this output. The collapse of world oil prices in the mid-1980's made the development of oil shale mines less likely in the short term.

See also **Oil shale.**

Rundstedt, Karl Rudolf Gerd von (1875-1953), was a German field marshal during World War II. He was Germany's most experienced general at the start of the war. He led his army successfully in the Polish and

French campaigns of 1939-1940. But Adolf Hitler interfered so much during his invasion of the Soviet Union in 1941 that he gave up his command and took over the German army of occupation in France. Hitler retired him from command in July 1944, but called him back to direct "The Battle of the Bulge," Germany's last desperate effort in the West. Rundstedt was born in Aschersleben, Germany.

Rune is any one of the characters of the earliest written alphabet used by the Germanic peoples of Europe. The oldest runic writings date back to the A.D. 200's. Most of the runic inscriptions known today were written before the 1000's. Most runes were carved in wood, but the majority of surviving runes were written in stone.

The word *rune* comes from a Gothic word meaning *secret.* Members of early Germanic tribes associated runes with secrecy or mystery because few people understood the inscriptions. Runic characters were probably first used by pagan priests in making charms and magic spells. The characters were also scratched on coins, jewellery, monuments, and slabs of stone or wood.

The earliest runes consisted almost entirely of straight lines, arranged singly or in combinations of two or more. Later runes had more complex forms.

Archaeologists have discovered more than 4,000 runic inscriptions. Over 3,000 of these writings were found in Sweden, and many dated from the 800's to the 1000's, the period of the Vikings. Other runic writings were discovered in Denmark, England, Germany, and Norway. By the 1000's, missionaries had converted the Germanic peoples to Christianity. Their conversion led to the introduction of the Latin alphabet, which eventually replaced runic characters.

See also **Kensington rune stone.**

Running is a vigorous form of exercise and a popular sport. Millions of people run because they enjoy the activity or want to be physically fit. Some runners compete in long-distance races that are not part of organized athletics meets. Most of these races are run on city streets and roads. This article includes information on such long-distance races, which are sometimes called *marathons.* For information about other kinds of running events, see **Athletics.**

Some people use the terms *running* and *jogging* interchangeably. However, running is usually considered faster than jogging. In addition, people jog only to exercise, not to compete against others.

Running requires no special skills or facilities. The only equipment needed is well-cushioned, flexible shoes and comfortable clothing. People more than 35 years old should have a complete medical examination before starting a running programme.

Running is an effective form of exercise and a popular sport. These runners are competing in the New York City Marathon.

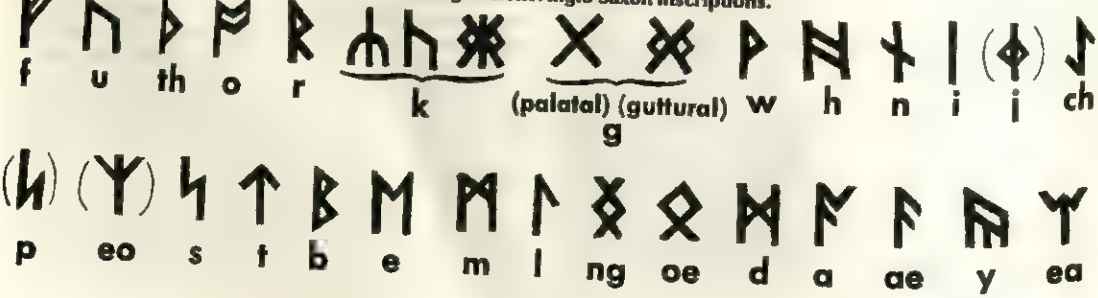
A daily programme of running improves a person's physical condition in many ways. Running is an *aerobic exercise*—that is, it promotes the circulation of oxygen through the bloodstream to the organs and tissues. It also builds up the heart and increases a person's endurance. Running strengthens the leg muscles and makes the body more limber. It helps control weight because runners burn up more than 62 calories per kilometre. In addition, running helps relieve emotional stress.

Running competitions have been held since ancient times. The Olympic Games feature several running events, including the marathon. Officially, a marathon is a race that covers 42.2 kilometres. However, the word *marathon* is often used for any race of several kilometres.

Many cities hold annual marathons. About 25,000 runners compete in the London Marathon, more than in any other marathon in the world. However, running events covering 10 kilometres are more popular than official marathons.

Running became extremely popular during the 1960's and 1970's. In the book *Aerobics* (1968), Kenneth Cooper, an American physician, brought attention to the advan-

Letters of the runic alphabet were used for writing ancient Anglo-Saxon inscriptions.



tages of running. Throughout the world, a large number of newspaper and magazine articles described the benefits of running, and many more books about running have been published.

See also **Cross-country; Jogging; Marathon; Physical fitness.**

Runnymede (pop. 71,500) is a local government district in northwestern Surrey, England, lying alongside the River Thames. It includes Addlestone, Chertsey, and Egham. Many of the district's residents work in London or at Heathrow Airport.

The district takes its name from Runnymede meadow, which it includes. This meadow lies on the south bank of the River Thames at Egham. On June 15, 1215, either at Runnymede meadow or on a nearby island in the river, the barons of England forced King John to grant the document known as *Magna Carta.* This document granted many rights to the English aristocracy, and formed the early basis of the British constitution.

See also **Magna Carta; Surrey.**

Runway. See **Airport** (Runways; picture).

Runyon, Damon (1880-1946), was an American writer. His first collection of stories, *Guys and Dolls* (1931), told the comic adventures of New York City gamblers, gangsters, and characters of the sporting world. He told these and later stories in imaginative slang, and they became popular. His books include *Tents of Trouble* (verse, 1911), *Blue Plate Special* (1934), *Money from Home* (1935), *Take It Easy* (1938), and *My Wife Ethel* (1939).

Alfred Damon Runyon was born in Manhattan, Kansas. After serving in the Spanish-American War (1898), he worked from 1900 to 1910 on newspapers in the West. In 1911, he became a sportswriter for the *New York American.*

Rupee is the chief monetary unit of India and the basic unit in India's decimal currency system. It is divided into 100 smaller units called *paise.* Paise circulate as nickel,

A rupee coin of India pictures Jawaharlal Nehru, India's first prime minister, *left.* The image of three lions on the other side, *right,* is India's national emblem.

copper-nickel, or bronze coins. Ten million rupees, or 100 *lakhs,* are called a *crore.* The monetary systems of Mauritius, Nepal, Pakistan, and Sri Lanka are also based on rupees. But all of these rupees have different monetary values. For the value of the rupee, see **Money** (table: Exchange rates).

Rupert, Prince (1619-1682), a German nephew of Charles I, became commander in chief of the Royalist forces in the English Civil War. Early in the war, Rupert's dashing cavalry charges were the most powerful weapon of the Royalist forces. But his cavalry lacked discipline. The Parliamentary cavalry learned from Rupert's recklessness.

Prince Rupert

Rupert was born at Prague, in what was then Bohemia. He fought in the Netherlands and came to England in 1635. In the Civil War, Rupert took part in the battles of Worcester, Edgehill, Marston Moor, and Naseby. Despite his bravery, he gained little success against the superior might of the Parliamentary forces.

In 1646, he took command of the Royalist fleet. Robert Blake defeated him in 1650. Rupert then spent two years as a pirate in the West Indies and eight more in Europe before returning to England in 1660. He fought as an admiral in the Dutch wars.

Prince Rupert was an amateur scientist. He was a pioneer of *mezzotint,* a method of copperplate engraving, and made several improvements in guns and cannons. Prince Rupert was an early member of the Royal Society. He helped finance exploration in the Hudson's Bay area of North America, and was a founder of the Hudson's Bay Company.

Rupert, Anton (1916-), a South African businessman and conservationist, built the multinational Rembrandt Group.

Anthony Edward Rupert was born in Graaff-Reinet, in the Cape Province. He trained as an industrial chemist and lectured at the University of Pretoria. In 1939, he started the Voorbrand Tobacco Company, which grew into the Rembrandt Group. Rupert became a major patron of the arts in South Africa. He became a member of the executive of the South African Academy of Arts and Science. He served as president of the South African Nature Foundation, and as a vice president of the World Wildlife Fund. He also chaired Historical Homes of South Africa, and was responsible for the restoration of historical buildings in Graaff-Reinet.

Rupture. See **Hernia.**

Rural life. See **Agriculture.**

Rurik. See **Union of Soviet Socialist Republics** (History: Early days).

Ruse, James (1760-1837), was given the first grant of land in New South Wales, Australia. His tombstone in Campbelltown erroneously claims that he sowed the first grain in the colony. The first private wheat grower was, in fact, Richard Johnson, Australia's first member of the clergy. Ruse did, however, grow the first commercial crop of wheat in the colony, at his farm, *Experiment Farm.* His work demonstrated that a small landholder in New South Wales could support himself without government backing.

Ruse was born at Launceston, in Cornwall, England. He was convicted of housebreaking in 1782, and was transported to New South Wales in the First Fleet in 1788. His sentence expired in 1789, but he asked to settle in the colony. Governor Phillip provided him with a hut and 0.4 hectare of land near Parramatta, where Ruse

sowed wheat and maize in 1790. That same year, Ruse married Elizabeth Perry, a former convict.

In 1793, Ruse sold his farm to John Harris, a surgeon, who built Experiment Farm Cottage on the land in 1798. The cottage still stands in Ruse Street, Parramatta.

Rush is the common name for a group of grasslike plants that generally grow in marshes and meadows, and sometimes in standing water. The true rushes belong to one family. They have round stems with three rows of leaves, and their tiny flowers are greenish or brown. The stems are sometimes filled with a white pith. The small seed pod contains many dustlike brown seeds. The *slender rush* is a wiry, dark-green plant that often grows on damp paths and lawns. Most other species grow in marshes or damp meadows. Rushes are used to weave baskets, mats, and chair seats. At one time, the pith of the stems was used for wicks in candles, called *rushlights.* Various plants called rushes are not true rushes. *Scouring rushes,* also called *horsetails,* are related to the ferns (see **Horsetail**). *Bulrushes* are actually sedges (see **Bulrush**).

Scientific classification. Rushes belong to the rush family, Juncaceae. The slender rush is *Juncus tenuis.*

Rush, Benjamin (1745-1813), was an American doctor and a prominent figure in the public life of his time.

Rush was born in Byberry, Pennsylvania. He graduated from Princeton University at the age of 15. In 1768, he received his degree in medicine from the University of Edinburgh. In 1783, Rush became a staff member of the Pennsylvania Hospital. His work at the hospital aroused his interest in social reform and, in 1786, he established the first free *dispensary* (clinic) in the United States.

Rush helped found the first American antislavery society, and Dickinson College. He served as a member of the Continental Congress, and signed the Declaration of Independence. During the American Revolution, Rush served as surgeon general in the Continental Army.

Rush, William. See **Sculpture** (American sculpture).

Rushcliffe (pop. 94,900) is a local government district in Nottinghamshire, England. It is a large, mainly agricultural area in the southern part of the county. There is a coal mine at Cotgrave, and Rushcliffe has one of the largest power stations in Britain, at Ratcliffe on Soar. The district includes Trent Bridge Cricket Ground, Nottingham Forest Football Ground, and the International Water Sports Centre at Holme Pierrepoint. See also **Nottinghamshire.**

Rushlight. See **Rush.**

Rushmoor (pop. 80,400) is a local government district in Hampshire, England, that includes several military establishments. Aldershot is the base of several army institutions, and Farnborough is the site of the Royal Aircraft Establishment. The district has little agriculture. Industries include the manufacture of electronics goods and precision instruments, and poultry packing. See also **Hampshire.**

Ruskin, John (1819-1900), was probably the most influential English critic of the 1800's. His many writings on art, literature, and social issues helped form the tastes of Victorian England.

Ruskin was born in London. While a student at Oxford University, he became a strong supporter of the British artist J. M. W. Turner, whose paintings had aroused much controversy. Ruskin's first book, *Modern Painters I* (1843), defended Turner's style (see **Turner, J. M. W.**). Ruskin's other works on art and architecture include four more volumes of *Modern Painters* (1846-1860), *The Seven Lamps of Architecture* (1849), and *The Stones of Venice* (three volumes, 1851-1853).

Ruskin believed that education, morality, and healthy social conditions were needed to produce good art. As a result, he concerned himself with social and economic issues. In lectures, essays, and books, Ruskin questioned the operations and motives of the free enterprise system. He attacked the quality of mass-produced products and encouraged workers to be artistically creative. His ideas had little political effect, but they inspired many young people. His writings on social issues include four essays, published as *Unto This Last* (1862), and *Fors Clavigera,* a series of letters to British workers published from 1871 to 1884.

In his last years, Ruskin had periods of depression and mental illness. Ruskin's last important work was an unfinished autobiography, *Praeterita,* written from 1885 to 1889.

Russell is the name of one of England's most famous families. Its best-known members included Bertrand Russell, a mathematician and philosopher, and Lord John Russell, a prime minister (see **Russell, Bertrand; Russell, Lord John**). Several other members became prominent in politics.

John Russell (1486?-1555) distinguished himself as a soldier and diplomat during the reign of King Henry VIII. In 1549, he was made the first Earl of Bedford. Francis Russell (1593-1641) played an important part in Parliament's struggle to limit the power of King Charles I. William Russell (1613-1700) switched his support from Parliament to Charles I and then back to Parliament during the English Civil War in the 1640's.

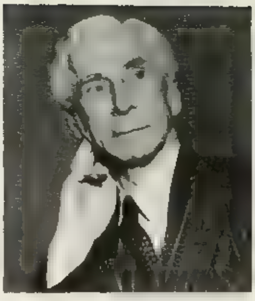
Hastings William Sackville Russell (1888-1953) was a pacifist. He defended some of Adolf Hitler's policies during World War II. John Robert Russell (1917-   ) was a journalist and farmer in South Africa. He made his land at Woburn a public park in 1955.

Russell (pop. 1,500), in the Bay of Islands in the North Island of New Zealand, is the oldest European settlement in New Zealand. It was originally called *Kororareka.* Whalers established it as a refitting base in the early 1800's.

In 1844, Kororareka was renamed *Russell.* The name was chosen to honour Lord John Russell, the British secretary of state for the colonies. Maiki Hill rises to the north of the present town of Russell. The British set up a flagstaff there. Maoris, led by the chief Hone Heke, cut down the flagstaff on the hill four times during 1844 and 1845. Heke's defiance of British rule led ultimately to the first of the New Zealand Wars.

Russell, Bertrand (1872-1970), was a British philosopher and mathematician. Russell ranks among the greatest philosophers of the 1900's. He has also been called the most important *logician* (expert in logic) since the ancient Greek philosopher Aristotle.

Russell made his most important contributions in formal logic and the theory of knowledge. However, his influence extends far beyond these fields. Russell developed a prose style of extraordinary clarity, wit, and passion. He received the 1950 Nobel Prize for literature.



Bertrand Russell

Russell became an influential and controversial figure on social, political, and educational issues. He was an outspoken pacifist and advocated liberal attitudes toward sex, marriage, and methods of education. Russell was a critic of World War I (1914-1918). He was imprisoned in 1918 for statements considered harmful to British-American relations, and again in 1961 for "incitement to civil disobedience" in a campaign for nuclear disarmament.

Russell made his major contributions to philosophy and mathematics in the early 1900's. He wanted to derive all of mathematics from logic, thus putting it on a sure foundation. Russell collaborated with the English mathematician and philosopher Alfred North Whitehead on the monumental three-volume *Principia Mathematica* (1910-1913). This work attempts to show that all pure mathematics follows from premises that are strictly logical and uses only those concepts that can be defined in purely logical terms. Although Russell's ideas have been refined and corrected by later mathematicians, all modern work in logic and the foundations of mathematics begins with his ideas.

Russell made important contributions to the history of philosophy in such books as *A Critical Exposition of the Philosophy of Leibniz* (1900) and *A History of Western Philosophy* (1945). He expressed his social and political ideas in a number of works, including *German Social Democracy* (1896), *Roads to Freedom* (1918), *Power* (1938), and *Authority and the Individual* (1949). Russell also influenced morality and education in many essays and in such books as *Why I Am Not a Christian* (1927), *Marriage and Morals* (1929), and *The Conquest of Happiness* (1930). Russell wrote many accounts of his life, including a three-volume autobiography published from 1967 to 1969.

Russell was born near Trellek, Wales, north of Chepstow. His full name was Bertrand Arthur William Russell. He was a member of an old and noble family. In 1931, on the death of his older brother, he inherited the family title and became Earl Russell.

Russell, Charles Marion (1864-1926), was an American painter and sculptor famous for his scenes of cowboys and life in the West. Russell's work shows action and great detail, with authentic backgrounds and settings. Russell taught himself art. He worked almost equally well with pen-and-ink, oil paint or water colour, and clay.

Russell was born in St. Louis. As a child, he loved to sketch and model animals, cowboys, and Indians. Because of his interest in the West, his parents let him visit the Montana Territory when he was 16 years old. He quickly made Montana his permanent home. Russell earned his living as a hunter for 2 years and then worked as a cowboy for about 10 years. He lived with the Blood Indians in Canada one winter. His experiences provided material for his paintings and sculptures.

In 1892, Russell gave up cowboy living so that he could paint and sculpt full-time. Many of his paintings and sculptures can be seen at the Montana Historical Society in Helena and at the Russell Museum in Great Falls, Montana. His statue represents Montana in Statuary Hall in the U.S. Capitol.

See also **Cowboy** (picture); **United States** (Arts [picture]).

Russell, Sir Edward John (1872-1965), a chemist, became one of the foremost agriculturalists in the world. From 1912 to 1943, he was director of Rothamsted Experimental Station, in Hertfordshire, England.

Russell pioneered research into the structure of soil, the nutrition of plants, and the problems of food production. He strongly advocated the use of artificial chemicals to promote plant growth. Russell was born at Frampton, in Gloucestershire. He was educated at the University of Wales and at Manchester University. He received a knighthood in 1922.

Russell, George William (1867-1935), was an Irish poet, painter, and journalist. He was a leader of the Irish Literary Revival, a movement that began in the late 1800's. This movement encouraged works based exclusively on Irish culture, as distinct from English culture.

Russell's mystical poetry and paintings reflect his deep love of nature. He developed a personal religion that sought spiritual truths in nature. Russell produced over 20 volumes of poetry, including *Homeward: Songs by the Way* (1894) and *Collected Poems* (1913, 1926). Russell was born in Lurgan, in what is now Northern Ireland. He spent most of his adult life as a journalist in Dublin. He wrote under the pen name "AE," which he took from a printer's error on one of his essays. Russell was an authority on farming and devoted much time to improving Irish agriculture.

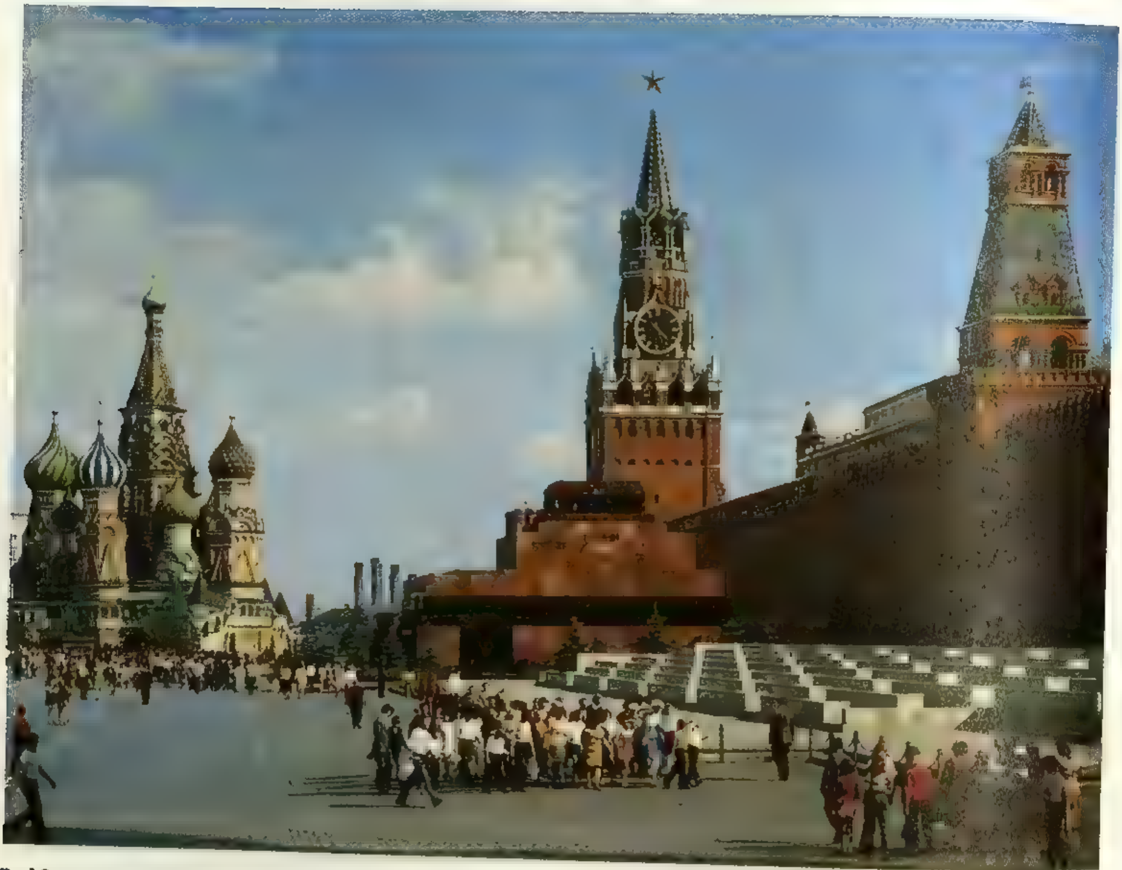
Russell, Lord John (1792-1878), first Earl Russell, a Whig statesman, was one of the champions of the Reform Act of 1832. This Act extended the vote and altered many parliamentary constituencies (see **United Kingdom, History of the** [England after 1763]). Russell also helped to establish civil registration of births, deaths, and marriages, and reduce the number of offences punished by hanging.

Russell was born in Westminster, the third son of the sixth Duke of Bedford. He first entered Parliament in 1813, and first held office in 1830 as paymaster-general. He served as home secretary and later as colonial secretary in Lord Melbourne's government. From 1846 to 1852 he was prime minister, and held high office in a number of other administrations.

Russell was created Earl Russell in 1861. In 1865 and 1866 he was again prime minister. He was the grandfather of Bertrand Russell.

Russell, John (1858-1930), was an Australian impressionist painter. He spent about 40 years of his life in England and France, where he produced most of his best work.

John Peter Russell was born in Sydney. In 1881, he left Sydney to study art in London. The Australian painter Tom Roberts was on the same ship as Russell, and the two artists became friends. Later, in France, Russell became friendly with many impressionist painters, including Vincent van Gogh and Claude Monet. He returned to live in Sydney in 1923.



Red Square in Moscow, Russia's capital and largest city, is the site of such famous landmarks as St. Basil's Cathedral, *left,* V. I. Lenin's tomb, *centre,* and the Kremlin, *right.* The large plaza took its name in Russian from an old word meaning both *beautiful* and *red.*

Russia

Russia is the world's largest country in area. It is almost twice as big as Canada, the second largest country. From 1922 until 1991, Russia was the biggest republic in the Soviet Union, the most powerful Communist country in the world. In the 1980's, many of the union republics began making strong demands for greater control of their own affairs or for independence. Independence moves by the republics gained strength after a failed coup in 1991. In that year, the Soviet Union broke apart, and Russia began to set up a new political, legal, and economic system.

Russia extends from the Arctic Ocean south to the Black Sea and from the Baltic Sea east to the Pacific Ocean. It covers much of the continents of Europe and Asia. Moscow, the capital, is one of the world's largest cities in population. St. Petersburg, on the coast of the Baltic Sea, is Russia's chief seaport.

Most of Russia's people are ethnic *Russians*—that is, descendants of an early Slavic people called the Russians. More than 100 minority nationalities also live in Russia. Approximately three-quarters of the people make their homes in urban areas. Russian cities have better schools and health-care facilities than the rural areas do. However, the cities suffer from overcrowding and from frequent shortages of many consumer goods, including food and clothing.

Russia has abundant natural resources, including vast deposits of petroleum, natural gas, coal, and iron ore. However, many of these reserves lie far from settled areas. Russia's harsh, cold climate makes it difficult to take advantage of many of the country's valuable resources.

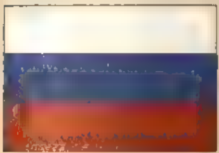
Russia traces its history back to a state that emerged in Europe among the East Slavs during the 800's. Over time, large amounts of territory and many different peoples came under Russian rule. For hundreds of years, *czars* (emperors) and empresses ruled Russia. They had almost complete control over most aspects of Russian life. Under these rulers, the country's economic development lagged behind the rapid industrial progress that began in Western Europe in the 1700's. Most of the people were poor, uneducated peasants.

Russia in brief

General information

Capital: Moscow.
Official language: Russian.
Official names: *Rossiya* (Russia) or *Rossiyskaya Federatsiya* (Russian Federation).

Largest cities (1990 official estimates)
Moscow 8,801,000
St. Petersburg 4,468,000



The Russian flag has stripes of white, blue, and red. It was adopted in 1991. The Russian Empire used the flag from 1699 to 1918.

The state seal was adopted in 1993. It includes symbols of the Russian Empire.

Land and climate

Land: Russia is the world's largest country in area. It covers a large part of both Europe and Asia. It has coastlines on the Arctic Ocean, Baltic Sea, Black Sea, Caspian Sea, and Pacific Ocean. Russia borders eight European countries, three Asian countries, and three countries with lands in both Europe and Asia. Much of the west of the country is a large plain.

The Ural Mountains separate Europe and Asia. Siberia, east of the Urals, has low western plains, a central plateau, and a mountainous wilderness in the east. Major Russian rivers include the Lena in Asia and the Volga in Europe. Lake Baikal in Siberia is the world's deepest lake.

Area: 17,075,400 km². *Greatest distances*—east-west, 9,650 km; north-south, 4,500 km.
Elevation: *Highest*—Mount Elbrus, 5,642 m. *Lowest*—Coast of Caspian Sea, 28 m below sea level.
Climate: Most of Russia has long, bitterly cold winters and mild to warm—but short—summers. In northeastern Siberia, the country's coldest area, January temperatures average below −46 °C. Rainfall is moderate in most of Russia. Snow covers more than half of the country during six months of the year.

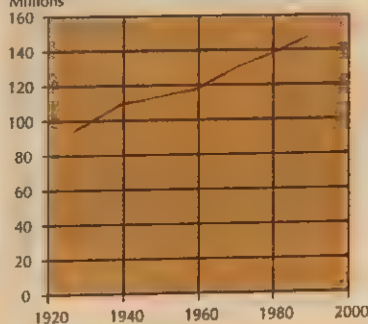
Government

Form of government: Republic.
Head of state: President.
Head of government: Prime minister.
Legislature: Russia's parliament is called the Federal Assembly. It consists of two houses—the 450-member State Duma and the 178-member Federation Council.
Executive: The president is the chief executive and most powerful official.
Judiciary: Highest court is the Constitutional Court.
Political subdivisions: 49 *oblasts* (regions), 6 *krais* (territories), 21 *autonomous* (self-governing) republics, 10 autonomous areas, 1 autonomous region. Moscow and St. Petersburg each have special region status. All of the political subdivisions are divided into *raions* (districts).

People

Population: *1996 estimate*—150,638,000. *1989 census*—147,400,537. *2001 estimate*—155,217,000.
Population density: 9 people per km².
Distribution: 74 per cent urban, 26 per cent rural.
Major ethnic/national groups: About 83 per cent Russian. Smaller groups include Tatars (or Tartars), Ukrainians, Chuvash, Bashkirs, Belarusians, Mordvins, Chechen, Germans, Udmurts, Mari, Kazakhs, Avars, Jews, and Armenians.
Major religions: The Russian Orthodox Church is the largest religious group. Other religious groups include Muslims, Protestants, Roman Catholics, and Jews.

Population trend



Year	
1926	93,459,000
1939	109,277,000
1959	117,534,000
1970	130,090,000
1979	137,552,000
1989	147,401,000

Economy

Chief products: *Agriculture*—barley, cattle, flax, fruit, oats, pigs, potatoes, rye, sheep, sugar beet, sunflowers, wheat. *Fishing*—cod, haddock, herring, salmon. *Manufacturing*—chemicals, construction materials, electrical equipment, iron and steel, machinery, paper, timber. *Mining*—coal, iron ore, manganese, natural gas, nickel, petroleum, platinum-group metals.
Money: *Currency unit*—rouble. One rouble = 100 kopecks.
Foreign trade: *Major exports*—chemicals, machinery, minerals, natural gas, paper products, petroleum, wood products. *Major imports*—consumer goods, food and beverages, industrial equipment, machinery. *Major trading partners*—former Soviet republics, Czech Republic, France, Germany, Italy, Japan, the United States.

Fields of wheat spread over vast areas of Russian farmland. Russia is one of the world's major producers of wheat and other grains.

Scene from a Kirov Ballet production of *Don Quixote*

Russian ballet troupes perform throughout the world. They are famous for their skill and beauty.

Snow covers more than half of Russia for six months of the year. This village is near the city of Irkutsk in Siberia.

Russia made many great contributions to the arts during the 1800's. Such authors as Anton Chekhov, Fyodor Dostoevsky, and Leo Tolstoy wrote masterpieces of literature. Russian composers, including Modest Mussorgsky, Nikolai Rimsky-Korsakov, and Peter Ilich Tchaikovsky, created music of lasting greatness. Russians also made valuable artistic contributions in the fields of architecture, ballet, and painting.

Opposition to the czars' absolute power increased during the late 1800's and the early 1900's. Revolutionaries overthrew the Russian government in 1917. The next year, Russia became the Russian Soviet Federative Socialist Republic (R.S.F.S.R.). In 1922, the R.S.F.S.R. and three other republics established a new nation called the Union of Soviet Socialist Republics (U.S.S.R.), also known as the Soviet Union. The R.S.F.S.R. became the largest and most influential republic of the Soviet Union, which grew to 15 republics by 1956. In 1991, Communist rule in the Soviet Union collapsed, and the country broke apart. Russia and 10 other republics formed a new, loose federation called the Commonwealth of Independent States.

After the breakup of the Soviet Union, Russia entered a transitional period. The Communist leaders of the Soviet Union had controlled all aspects of the country's economy and government. Russia's new national government worked to transform the country from a state-controlled, managed economy to one based on private enterprise and a free market for goods and services. The government also began to establish new political and legal systems in Russia.

This article deals with Russia from its early history to the present. For more detailed information about the history of Russia between 1922 and 1991—when it was part of the Soviet Union—see **Union of Soviet Socialist Republics.**

National government. In 1992, Russia established a *transitional* (temporary) government headed by Boris Yeltsin. Yeltsin had been elected president of the R.S.F.S.R. in 1991. After the breakup of the Soviet Union, Yeltsin continued to serve as president of Russia.

The president of Russia is the head of state. A prime minister acts as the head of government. The government has a cabinet called the Council of Ministers.

A parliament makes Russia's laws. It consists of the Congress of People's Deputies and the Supreme Soviet. *Soviet* is a Russian word meaning *council.* The Congress of People's Deputies has more than 1,000 members. This body is Russia's highest legislative authority. The Supreme Soviet has two houses—the Council of the Federation and the Council of Nationalities. The members of the Supreme Soviet are elected from among the members of the Congress of People's Deputies.

The transitional Russian government suffered from instability. Many former Communists and Soviet Union leaders opposed the economic and governmental reforms proposed by President Yeltsin. These opponents included many members of parliament. In September 1993, Yeltsin dissolved the parliament. See *The new nation* section at the end of this article.

Local government. Russia contains 49 administrative units called *oblasts* (regions) and 6 large, sparsely settled *krais* (territories). Russia also has about 30 other territories, each of which has a dominant nationality group. These territories are known as autonomous republics and autonomous areas. There is also one autonomous region. *Autonomous* means *self-governing,* but these units actually had little control over their own affairs in the Soviet Union. The future of the autonomous units is unclear, because some of their populations are pressing for increased self-rule.

All of these divisions may contain smaller units called *raions* (districts). Councils called soviets manage local affairs in both urban and rural areas. In October 1993, Yeltsin ordered these soviets to be replaced by newly elected, smaller councils.

Politics. The Communist Party was the only legal political party in the U.S.S.R. until March 1990. At that time, the Soviet Constitution—which gave the Communist Party its broad powers—was amended. A loose coalition of political parties with a democratic platform, known as the Democratic Russia Movement, began to play a key role in the reform movement. The Democratic Russia Movement secured Yeltsin's victory in free presidential elections in June 1991. The collapse of the Communist Party and the Soviet Union caused the Democratic Russia Movement to break apart. Groups that had opposed the Soviet Communist Party developed into separate political parties.

The Russian Christian Democratic Party backs a parliamentary democracy with a monarchy, based on law and principles of Christian morality. The Social Democratic Party calls for a political, social, and economic democracy in which each ethnic group can maintain its identity. It seeks to achieve its goals through social and legal revolution. The Democratic Party of Russia, which has attracted many intellectuals, wants to base the new Russian government on individual freedom and on private ownership of property. The Republican Party of the Russian Federation seeks political and economic freedom through rapid change to private ownership and a less centralized government. The People's Party of Free Russia formed in 1991 as a democratic party of Communists within the Communist Party of the Soviet Union. It later declared itself the sole successor to the Communist Party. A number of extremist groups, such as the Liberal Democratic Party, have also emerged.

New political parties continue to form in Russia to promote the interests of specific groups. However, Yeltsin suspended a number of parties following his confrontation with the parliament. All Russian citizens who are 21 years of age or older may vote in elections.

Courts. The former Soviet government had a political police system called the Committee for State Security, known as the KGB. The KGB could interfere with and influence the legal system, and major violations of human

The Congress of People's Deputies is the highest legislative authority in Russia. It has more than 1,000 members, who are elected by the Russian people.


Russia
political map
International boundary
Major road
Major railway
Canal
National capital
Other city or town
North Atlantic Ocean
Arctic
Svalbard (Norway)
Franz Josef Land
Barents Sea
Kara Sea
Novaya Zemlya
North
North Sea
Baltic Sea
Black Sea
Caspian Sea
Aral Sea
NORWAY
SWEDEN
FINLAND
DENMARK
GERMANY
POLAND
RUSSIA
LITHUANIA
LATVIA
ESTONIA
BELARUS
UKRAINE
GEORGIA
ARMENIA
AZERBAIJAN
TURKEY
IRAN
TURKMENISTAN
UZBEKISTAN
KAZAKHSTAN
CHINA
R U S
Oslo
Stockholm
Copenhagen
Helsinki
Tallinn
Riga
Minsk
Kiev
Moscow
St. Petersburg
Nizhniy Novgorod
Samara
Yekaterinburg
Novosibirsk
Kharkov
Volgograd
Baku
Tbilisi
Teheran
Tashkent
Almaty
Murmansk
Arkhangelsk
Vorkuta
Omsk
Chelyabinsk
Perm
Kazan
Ufa
Orenburg
Barnaul
Novokuznetsk
Qaraghandy
Rostov-on-Don
Astrakhan
Krasnodar
Saratov
Voronezh
Norilsk
Dudinka
Igarka
Dickson
Yamal Peninsula
Gydan Peninsula
Kola Peninsula
Kanin Peninsula
North Cape
Kolguyev I.
Belyy I.
East Longitude 60°
0
500
1,000
1,500
2,000
2,500
3,000
3,500


9
10
11
12
13
14
15
16
A
B
C
D
E
F
G
H
I
J
Ocean
Severnaya Zemlya
Cape Chelyuskin
Taymyr Peninsula
Laptev Sea
Bolshoy Begichev I.
Nordvik
Khatanga
Volochanka
Yessey
New Siberian Islands
Kotelny I.
Bolshoy Lyakhovskiy I.
Novaya Sibir
East Siberian Sea
Wrangel Island
Chukchi Sea
Diomede Is.
Kotzebue
Nome
UNITED STATES (Alaska)
Chukchi Peninsula
Provideniya
Beringovskiy
Gulf of Anadyr
Bering Sea
Arctic Circle
Pevek
Bilibino
Ambarchik
Chersky
Anadyr
Markovo
Kamenskoye
Omolon
Chokurdakh
Srednekolymsk
Kolyma
Druzhina
Kazachye
Tiksi
Siktyakh
Lena
Verkhoyansk
Batagay
Yana
Indigirka
Ugolnoye
Zyryanka
Ust-Nera
Susuman
Omsukchan
Sinegorye
Gizhiga
Magadan
Palana
Karagin Island
Ust-Kamchatsk
Commander Islands
Kamchatka Peninsula
Petropavlovsk-Kamchatskiy
Yelizovo
Okhotsk
Sea of Okhotsk
Khandyga
Aldan
Sangar
Udachnyy
Vilyuy
Vilyuysk
Yakutsk
Nyurba
Suntar
Kempendyay
Pokrovsk
Amga
Ust-Maya
Tura
Tunguska
Chernyshevskiy
Mirnyy
Olekminsk
Lensk
Tommot
Aldan
Ayan
Shantar Is.
Okha
Russia claims and occupies the Kuril Islands. But Japan also claims the southernmost Kurils.
Severo Kurilsk
Kuril Islands
Kurilsk
Aleksandrovsk-Sakhalinskiy
Tymovskoye
Sakhalin
Poronaysk
Uglegorsk
Makarov
Yuzhno-Sakhalinsk
Korsakov
Kholmsk
Tatar Strait
Nikolayevsk
Chumikan
Amgun
Amur
Chegdomyn
Komsomolsk
Amursk
Sovetskaya Gavan
Khabarovsk
Birobidzhan
Bikin
Dalnerechensk
Lesozavodsk
Spassk Dalniy
Arsenyev
Dalnegorsk
Ussuriysk
Artem
Nakhodka
Vladivostok
Sea of Japan
Wakkanai
Hokkaido
Sapporo
Aomori
Sendai
Niigata
JAPAN
Honshu
Nagoya
Kyoto
Osaka
Severo Yeniseyskiy
Vitim
Bodaybo
Chulman
Neryungri
Tynda
Zeya
Magdagachi
Svobodnyy
Belogorsk
Blagoveshchensk
Skovorodino
Mangui
Severobaikalsk
BAM LINE
Kirensk
Ust-Kut
Ust-Ilimsk
Bratsk
Bratsk Res.
Angara
Kansk
Krasnoyarsk
Tayshet
Nizhneudinsk
Tulun
Zima
Cheremkhovo
Usolye-Sibirskoye
Angarsk
Irkutsk
Ust-Ordynskiy
Ulan-Ude
Lake Baikal
TRANS-SIBERIAN RAILROAD
Romanovka
Mogocha
Nerchinsk
Shilka
Borzya
Chita
Khilok
Aginskoye
Krasnokamensk
Hailar
Petrovsk-Zabaykalskiy
Kyakhta
Kyzyl
Erzin
Hovsgol Lake
Zakamensk
Darhan
Erdenet
Ulan Bator
Choybalsan
Kerulen
Selenge
Tsetserleg
Uliastay
Altay
MONGOLIA
Saynshand
Hulun Lake
Arxan
Nenjiang
Yichun
Qiqihar
Harbin
Mudanjiang
Jilin
Baicheng
Changchun
CHINA
Shenyang
Fuxin
Jinzhou
Anshan
NORTH KOREA
Hamhung
Pyongyang
SOUTH KOREA
100° East Longitude
2,500
3,000
3,500
4,000
4,500 Miles
4,000
4,500
5,000
5,500
6,000
6,500
7,000 Kilometres

Russia map index

Cities and towns

Abakan	157,000	I	8
Abaza		J	8
Achinsk	122,000	H	8
Aginskoye		J	11
Ak Dovurak		J	8
Aldan		G	12
Aleksandrovsk Sakhalinskiy		G	15
Aleksin*	70,000	F	2
Aleysk		I	7
Almetyevsk	130,000	G	4
Ambarchik		C	13
Amderma		E	6
Amga		F	13
Amursk		H	15
Anadyr		B	15
Andropov, see Rybinsk			
Angarsk	267,000	I	10
Anzhero-Sudzhensk	108,000	H	8
Apatity	74,000	D	4
Arkhangelsk	419,000	D	4
Armavir	162,000	H	1
Arsenyev		I	15
Artem	71,000	I	15
Arzamas*	111,000	F	3
Asbest*	81,000	G	5
Asino		H	8
Astrakhan	510,000	H	2
Ayan		F	14
Azov*	79,000	G	1
Balakovo	200,000	G	3
Balashikha*	137,000	F	3
Balashov	97,000	G	3
Barnaul	603,000	I	7
Batagay		E	12
Bataysk*	95,000	G	2
Belgorod	306,000	F	2
Beloretsk	74,000	G	5
Belovo	116,000	I	8
Belyy Yar		H	8
Berdsk*	74,000	H	7
Berezniki	201,000	F	5
Beringovskiy		B	15
Bikin		I	15
Bilibino		C	14
Birobidzhan	77,000	H	14
Biysk	234,000	I	8
Blagoveshchensk	208,000	H	13
Bodaybo		G	11
Borisoglebsk		G	2
Borzya		I	12
Bratsk	258,000	H	10
Brezhnev, see Naberezhnyye Chelny			
Bryansk	456,000	F	2
Bugulma	85,000	G	4
Buzuluk	79,000	G	4
Chapayevsk*	86,000	G	4
Chaykovskiy*	76,000	G	4
Cheboksary	429,000	F	4
Chegdomyn		H	14
Chelyabinsk	1,148,000	G	5
Cheremkhovo	73,000	I	10
Cherepovets	313,000	E	3
Cherkessk*	115,000	H	1
Chernogorsk*	77,000	I	9
Cherskiy		C	13
Chita	372,000	I	11
Chokurdakh		D	12
Chulmen		G	12
Chumikan		G	14
Chusovoy		G	5
Dalnegorsk		I	15
Dalnerechensk		I	15
Derbent	78,000	I	2
Dickson		D	8
Dimitrovgrad*	133,000	G	4
Druzhina		D	13
Dudinka		E	8
Dzerzhinsk	286,000	F	3
Egvekinot		B	15
Elektrostal*	153,000	F	3
Elista	80,000	H	2
Engels	183,000	G	3
Erzin		I	9
Gatchina*	78,000	D	3
Gizhiga		D	15
Glazov	105,000	F	4
Gorki, see Nizhniy Novgorod			
Gorno-Altaysk		I	8
Groznyy	401,000	H	2
Gubkin*	70,000	F	2
Gus-Khrustalnyy*	74,000	F	3
Igarka		F	8
Inta		E	6
Irkutsk	635,000	I	10
Ishim		H	6
Ivanovo	482,000	F	3
Izhevsk (Ustinov)	642,000	G	4
Kalinin, see Tver			
Kaliningrad (Konigsberg)	406,000	D	1
Kaliningrad*	161,000	F	3
Kaluga	314,000	F	2
Kamen-na-Obi		I	7
Kamenskoye		C	15
Kamensk Shakhtinskiy*	75,000	G	2
Kamensk-Uralskiy	208,000	G	5
Kamyshin	123,000	G	3
Kandalaksha		D	4
Kansk	110,000	H	9
Kazachye		D	12
Kazan	1,103,000	G	4
Kemerovo	521,000	H	8
Kempendyay		F	11
Khabarovsk	608,000	H	14
Khalmer-Yu		E	6
Khandyga		F	13
Khanty		G	6
Khasavyurt*	72,000	I	2
Khatanga		E	9
Khilok		I	11
Khimki*	135,000	F	3
Kholmsk		H	15
Kineshma*	105,000	F	3
Kirensk		H	10
Kirov	487,000	F	4
Kirovo-Chepetsk*	83,000	F	4
Kirovograd		G	8
Kirovsk		D	8
Kiselevsk	128,000	H	8
Kislovodsk	116,000	H	1
Klin*	94,000	E	3
Klintsy*	71,000	F	8
Kolomna	163,000	F	3
Kolpashevo		H	8
Kolpino	143,000	E	3
Komsomolsk	318,000	H	14
Kondopoga		D	3
Konigsberg, see Kaliningrad			
Konosha		E	4
Kopeysk	134,000	G	5
Korsakov		H	15
Koslan		E	5
Kostroma	280,000	F	3
Kotelnich		F	4
Kotlas		F	4
Kovrov	161,000	F	3
Krasino		D	8
Krasnodar	627,000	G	1
Krasnogorsk*	86,000	H	15
Krasnokamensk		I	12
Krasnokamsk		F	8
Krasnoturinsk		F	8
Krasnoyarsk	922,000	H	9
Kropotkin*	73,000	G	2
Kumertau		H	4
Kungur	82,000	G	5
Kur	430,000	F	2
Kurgan	360,000	H	5
Kuybyshev, see Samara			
Kuznetsk	97,000	G	3
Kyakhta		I	10
Kyzyl	73,000	I	9
Labytnangi		E	6
Leningrad, see St. Petersburg			
Leninsk-Kuznetskiy	134,000	H	8
Lensk		G	11
Lesosibirsk		H	9
Lesozavodsk		I	15
Lipetsk	455,000	F	2
Liski		G	2
Lysva	76,000	G	5
Lyubertsy	165,000	F	3
Magadan	154,000	E	14
Magdagachi		H	13
Magnitogorsk	443,000	H	5
Makarov		H	15
Makhachkala	327,000	I	2
Mansiysk		G	5
Markovo		C	15
Maykop*	151,000	G	1
Mezen		E	5
Mezhdurechensk*	107,000	F	5
Miass	169,000	G	5
Michurinsk*	109,000	F	3
Mineralnyye Vody	72,000	H	2
Mirnyy		F	11
Mogocha		H	12
Monchegorsk		C	4
Moscow	8,801,000 †8,967,000	F	3
Murmansk	472,000	D	4
Murom	125,000	F	3
Mytishchi*	153,000	F	3
Naberezhnyye Chelny (Brezhnev)	507,000	G	4
Nadym		F	7
Nakhodka	163,000	I	15
Nalchik	237,000	H	1
Naryan-Mar		E	5
Neftekamsk*	109,000	G	4
Nefteyugansk	72,000	G	7
Nerchinsk		I	12
Neryungri		G	12
Nevinnomyssk	122,000	H	1
Nikel		C	4
Nikolayevsk		G	14
Nizhnekamsk*	193,000	G	4
Nizhneudinsk		H	9
Nizhnevartovsk	246,000	G	7
Nizhniy Novgorod (Gorki)	1,443,000	F	3
Nizhniy Tagil	440,000	G	5
Noginsk*	123,000	F	3
Nordvik		D	10
Norilsk	173,000	E	8
Novgorod	232,000	E	3
Novocheboksarsk*	117,000	G	3
Novocherkassk	188,000	G	2
Novokuybyshevsk*	114,000	G	3
Novokuznetsk	601,000	I	8
Novomoskovsk		F	2
Novorossiysk	188,000	G	1
Novoshakhtinsk*	108,000	G	1
Novosibirsk	1,443,000	H	7
Novotroitsk	107,000	H	4
Novyy Urengoy		F	7
Nyurba		F	11
Obinsk*	102,000	F	3
Odintsovo*	127,000	F	2
Okha		G	15
Okhotsk		F	14
Oktyabrskiy	106,000	G	4
Olekminsk		G	12
Omsk	1,159,000	H	6
Omsukchan		D	14
Onega		D	4
Ordzhonikidze, see Vladikavkaz			
Orekhovo-Zuevo	137,000	F	3
Orel	342,000	F	2
Orenburg	552,000	H	4
Orsk	271,000	G	4
Palana		D	15
Pavlovo*	70,000	F	3
Pavlovskiy Posad*	71,000	F	3
Pechora		E	6
Penza	548,000	G	3
Perm	1,094,000	G	5
Pervomaysk*	76,000	F	3
Pervouralsk	143,000	G	5
Petrodvorets*	77,000	D	3
Petropavlovsk-Kamchatskiy	271,000	E	16
Petrovsk Zabaykalskiy		I	11
Petrozavodsk	274,000	D	3
Pevek		B	14
Plesetsk		E	4
Podkajmennaya Tunguska		G	8
Podolsk	209,000	F	3
Pokrovsk		F	12
Poronaysk		G	15
Prokopyevsk	274,000	I	8
Provideniya		A	15
Pskov	206,000	E	2
Pushkin*	91,000	D	3
Pushkino*	74,000	F	3
Pyatigorsk*	130,000	H	1
Ramenskoye*	84,000	F	3
Romanovka		H	11
Roslavl		E	2
Rostov-on-Don	1,025,000	G	2
Rubtsovsk	172,000	I	7
Ryazan	522,000	F	3
Rybinsk (Andropov)	252,000	E	4
Rzhev	70,000	E	2
St. Petersburg (Leningrad)	4,468,000 †5,020,000	D	3
Salavat	151,000	H	4
Salekhard		E	6
Salsk		G	2
Samara (Kuybyshev)	1,258,000	G	4
Sangar		F	12
Saransk	316,000	F	3
Sarapul	111,000	G	4
Saratov	909,000	G	3
Segezha		D	4
Sergino		F	6
Sergiyev Posad (Zagorsk)	115,000	E	3
Serov	104,000	G	5
Serpukhov	144,000	F	3
Severobaikask		H	11
Severodvinsk	250,000	D	4
Severo Kurilsk		F	16
Severomorsk		D	4
Severo Yeniseyskiy		G	9
Shadrinsk	86,000	G	5
Shakhtersk*	71,000	G	15
Shakhty	227,000	G	2
Shchekino*	70,000	F	2
Shchelkovo*	109,000	F	3
Shilka		I	12
Shostka*	84,000	E	2
Shuya*	72,000	D	4
Siktyakh		E	11
Sinegorye		E	14
Skovarodino		H	11
Smolensk	346,000	E	2
Sochi	339,000	H	1
Solikamsk	110,000	F	5
Sovetskaya Gavan		H	15
Spassk Dalniy		I	15
Srednekolymsk		D	13
Stalingrad, see Volgograd			
Staryy Oskol*	178,000	F	2
Stavropol	324,000	H	1
Sterlitamak	250,000	G	4
Stupino*	72,000	F	3
Suntar		F	11
Surgut	256,000	G	7
Susuman		E	14
Sverdlovsk, see Yekaterinburg			
Svobodnyy		H	13
Syktyvkar	235,000	F	5
Syzran	174,000	G	3
Taganrog	293,000	G	1
Tambov	307,000	F	3
Tara		H	7
Tatarsk		H	7
Tavda		G	6
Tayshet		H	9
Tikhoretsk		G	1
Tiksi		D	11
Tilichiki		D	15
Tobolsk	72,000	G	6
Tolyatti	642,000	G	3
Tommot		G	12
Tomsk	506,000	H	8
Torey*	87,000	I	10
Troitsk	90,000	H	5
Troitsko Pechorsk		F	5
Tula	543,000	F	2
Tulun		H	10
Tura		F	9
Turukhansk		F	8
Tver (Kalinin)	454,000	E	2
Tymoskoye		G	15
Tynda		H	12
Tyumen	487,000	G	6
Udachnyy		F	10
Ufa	1,094,000	G	4
Uglegorsk		G	15
Ugolnoye		D	13
Ukhta	111,000	E	5
Ulan-Ude	359,000	I	11
Ulyanovsk	638,000	G	3
Usolye-Sibirskoye	107,000	I	10
Ussuriysk	159,000	I	14
Ust-Ilimsk	93,000	H	10
Ustinov, see Izhevsk			
Ust-Ishim		G	6
Ust-Kamchatsk		E	16
Ust-Kut		H	10
Ust-Maya		F	13
Ust-Nera		E	13
Ust-Ordynskiy		I	10
Velikiye Luki	115,000	E	2
Verkhoyansk		E	12
Vilyuysk		F	11
Vitim		G	11
Vladikavkaz (Ordzhonikidze)	303,000	H	2
Vladimir	353,000	F	3
Vladivostok	643,000	J	15
Volgodonsk*	178,000	G	2
Volgograd (Stalingrad)	1,005,000	G	2
Volochanka		E	9
Vologda	286,000	E	3
Volzhskiy	275,000	G	2
Vorkuta	117,000	E	7
Voronezh	895,000	F	2
Voskresensk*	79,000	F	3
Votkinsk	104,000	G	4
Vyborg	79,000	D	3
Vyshniy Volochek	71,000	E	3
Yakutsk	191,000	F	12
Yaroslavl	636,000	E	3
Yartsevo		G	8
Yegoryevsk*	73,000	F	3
Yekaterinburg (Sverdlovsk)	1,372,000	G	5
Yelets	115,000	F	2
Yelizovo		E	16
Yessentuki*	82,000	H	1
Yessey		E	9
Yeysk*	75,000	G	1
Yoshkar-Ola	246,000	F	4
Yurga*	87,000	H	7
Yuzhno-Sakhalinsk	162,000	H	15
Zagorsk, see Sergiyev Posad			
Zakamansk		I	10
Zelenodolsk*	88,000	G	4
Zelenograd*	160,000	F	3
Zeya		H	13
Zheleznodorozhnyy*	84,000	F	3
Zheleznogorsk*	74,000	F	2
Zhukovskiy*	101,000	F	3
Zima		I	10
Zlatoust	208,000	G	5
Zyryanka		D	13

*Does not appear on map; key shows general location.
†Population of metropolitan area, including suburbs.
Sources: 1990 official estimates for places over 100,000; 1989 census for metropolitan areas; 1984 official estimates for other places.

rights took place. The KGB no longer exists in Russia. Today, Russia has two security agencies. The Russian Security Services handles internal security, and the Foreign Intelligence Service collects information from other countries. In addition, new laws are being passed to protect the rights of all Russian citizens. The *procurator-general,* the chief legal officer of Russia, is nominated by the president and approved by the Congress of People's Deputies.

Russia's highest court is called the Constitutional Court. This court, which was established in 1992, rules on the constitutionality of the country's laws. However, President Yeltsin suspended the Constitutional Court in 1993 shortly after he dissolved parliament. See *The new nation* section at the end of this article.

Russia's local courts are called *people's courts.* The judges of the local courts are elected by the people to five-year terms.

Armed forces. The Soviet Union had the largest armed forces in the world. About 4 million people served in its army, navy, and air force. Required military service for young men began at age 18 and lasted at least two years.

When the Soviet Union collapsed, command of the Soviet armed forces passed to the Commonwealth of Independent States. But several former republics—including Russia—also announced intentions to create their own armed forces. In 1992, Russia began to form its own armed forces and absorbed some of the former Soviet forces.

People

The people in Russia are distributed unevenly throughout the country. Most of the population live in the western (European) part of Russia. The more rugged and remote areas to the east are sparsely inhabited. For the total population, see the *Russia in brief* table with this article.

Population. About 83 per cent of Russia's people are of Russian ancestry. These ethnic Russians make up the largest group of Slavic peoples. Members of more than 100 other nationality groups also live in Russia. The largest groups include Tatars (or Tartars), Ukrainians, Chuvash, Bashkirs, Belarusians, Mordvins, Chechen, Germans, Udmurts, Mari, Kazakhs, Avars, Armenians, and Jews, who are considered a nationality group in Russia. Many of them live in Russia's autonomous territories. Remote parts of the Far North are sparsely inhabited by small Siberian groups, including Aleuts, Chukchi, Eskimos, and Koryaks. These northern peoples differ from one another in ancestry and language, but they share a common way of life shaped by the harsh, cold climate.

The government of the Soviet Union had granted Russians special privileges. It repressed the distinctive cultures of other nationalities and did not always uphold their rights. This policy sharpened resentment among some peoples. Today, pride in their culture and the desire for greater independence are growing among the members of many nationalities, including Russians.

Ancestry. Ethnic Russians are descended from Slavs who lived in eastern Europe several thousand years ago. Over time, migration split the Slavs into three subgroups—the East Slavs, the West Slavs, and the South Slavs. The Russians trace their heritage to the first East Slav state, Kievan Rus. This state emerged in the 800's.

Kievan Rus suffered repeated invasions by Asian tribes, including the Pechenegs, Polovtsians, and Mongols. The Mongol invasions forced some people to migrate to safer, forested regions near present-day Moscow. Moscow became an important Russian state in the 1300's. This area has remained at the heart of Russia ever since. But people of many ethnic groups have lived in Russia, especially since the 1500's, when extensive expansion and colonization began.

Language. Russian is the official language of Russia. Spoken Russian sounds fairly uniform from one end of the country to the other. Nevertheless, the language has three major regional accents—northern, southern, and central. The small differences rarely interfere with understanding. Russian is written in the Cyrillic alphabet (see **Alphabet** [The Cyrillic alphabet]). Many minority nationality groups in Russia have their own language and speak Russian as a second language.

Way of life

The government of the Soviet Union controlled many aspects of life in the country. It exerted great influence over religion, education, and the arts. The independence of Russia following the breakup of the Soviet Union brought greater freedom and triggered many other changes in the lives of the people.

City life. About three-quarters of Russia's people live in urban areas. Approximately 35 cities in Russia have populations over 500,000. Two of Russia's cities—Moscow and St. Petersburg—each have more than 4 million inhabitants.

Russian cities are crowded. Beginning in the 1930's, large numbers of people migrated from the countryside to urban areas. During World War II (1939-1945), bombs destroyed many houses and other buildings. These circumstances combined to create a housing shortage in Russian cities that continues to this day. Millions of city dwellers live in small apartments in high-rise buildings. The scarcity of housing forces some families to share kitchen and toilet facilities. Single-family houses are common in small towns and on the outskirts of large cities. But some of these houses lack indoor plumbing and other modern conveniences.

Shortages of food, services, and manufactured goods have been common features of city life in Russia. The shortages were widespread in 1992, when the government lifted price controls. When goods are available, they are often too expensive for most people to afford. Russian cities also face urban problems such as increased crime and environmental pollution.

Population density

The map on the right shows the population density throughout Russia. Most of Russia's people live in the western part of the country. Central and eastern Russia are sparsely inhabited.

Major cities

- More than 2 million inhabitants
- Less than 2 million inhabitants

Persons per sq. mi.	Persons per km²
More than 125	More than 50
60 to 125	25 to 50
25 to 60	10 to 25
5 to 25	2 to 10
Less than 5	Less than 2

Rural life. About a quarter of the Russian population live in rural areas. Single-family housing is common in these areas, but the Soviet government built many city-style apartment buildings. In the most remote areas of Russia, some homes lack gas, plumbing, running water, and electricity. In addition, the quality of education, health care, and cultural life is lower than in the cities. Rural shops are poorly stocked, offering even less selection than city shops. But food is more plentiful in rural areas than in the cities.

During the existence of the Soviet Union, most rural people worked on huge farms run by the government. After the Soviet Union collapsed, Russia began to break up these farms. New laws allow people to withdraw from the government farms and set up private farms.

Clothing. Most people in the Soviet Union wore plain, simple clothes. Shops offered little variety in clothing styles, and most people had only a few different outfits. In the 1970's, consumers began to demand greater variety in apparel. People preferred to buy imported Western clothing whenever it was available. As a result, clothing manufacturers began to pay more attention to style and quality. But scarcity, high cost, and Russia's cold climate continue to affect Russian clothing styles. When possible, rural dwellers buy their clothes in cities, where they find a wider selection.

Traditional Russian clothing consists of colourfully embroidered shirts and blouses, embroidered headwear, and shoes woven from *bast,* a tough fibre from the bark of certain trees. Rural dwellers wore these cos-

A Moscow family gathers for dinner at home. Most people in Russia eat their main meal at midday.

High-rise apartment buildings, such as those shown in the photograph above, house millions of people in Russia's cities. Nevertheless, a housing shortage persists in urban areas.

tumes on special occasions, such as weddings and holidays. But, the traditional costume is rarely worn today.

Food and drink. The Russian diet is hearty. Russians eat bread at virtually every meal. Beef, chicken, pork, and fish are popular main dishes. The most commonly eaten vegetables include beets, cabbage, carrots, cucumbers, onions, potatoes, radishes, and tomatoes. Russians are fond of soups and dairy products, and they consume large quantities of sugar. Frying remains a widespread method of preparing food.

Many Russian dishes are popular around the world. They include *blinis* (thin pancakes served with smoked salmon or other fillings and sour cream) and *beef Stroganoff* (beef strips cooked with onions and mushrooms in a sour cream sauce). Other favourite dishes include *borscht* (beet soup) and *piroshki* (baked or fried dumplings filled with meat and cabbage).

Typical breakfast foods include eggs, porridge, sausages, cheese, bread, butter, and jam. Most of the people eat their main meal at midday. It consists of a salad or appetizer; soup; meat or fish with potatoes or *kasha* (cooked buckwheat); and dessert, such as stewed fruit or pastries. In the evening, most Russians eat a light supper.

Russians drink large quantities of tea. Many people enjoy coffee, but it is expensive and often unavailable. *Kvass,* a beerlike beverage made from fermented black bread, is especially popular in summer. Russians also enjoy soft drinks and mineral water.

Vodka is Russia's traditional alcoholic beverage. Russians also drink wine, champagne, cognac, beer, and other alcoholic beverages. Alcohol abuse has been and remains a major social problem in Russia.

Health care in the Soviet Union was free. The Russian government remains committed to meeting the basic health-care needs of its people. An insurance programme to finance health care was introduced in 1993. A private health-care sector is emerging. The country has large numbers of doctors, nurses, hospitals, and other facilities. However, shortages of medicines and equipment, low wages, and bureaucracy continue to create problems. Bribery of health-care workers is common. Conditions in the country's rural areas are worse than in the cities.

Recreation. Russians enjoy watching television, reading, playing chess, going to the cinema, watching plays, visiting museums, walking, and taking part in sports. The government actively promotes athletic activities, especially team sports. Soccer is the most popular participant and spectator sport in Russia. Other popular

Shoppers wait to buy food. Such waiting is common in Russia's cities, which lack sufficient amounts of food and other consumer goods.

At outdoor markets, farmers sell produce that is fresher than that found in state shops, but more expensive. This market is in Krasnodar, a city in southwestern Russia.

sports include gymnastics, basketball, and such winter sports as ice hockey, ice skating, and skiing. Tennis is growing in popularity.

Russia has many athletic clubs, stadiums, recreational centres, and other sporting facilities. Schools provide physical education at all levels. There are also special sports camps and clubs for children and adults.

The people of Russia are avid nature lovers, and they enjoy spending time in the countryside. Many wealthy Russians have country cottages called *dachas.* There, they garden, hike, cycle, swim, fish, gather mushrooms, and take part in other outdoor activities.

Most people in Russia take holidays in the summer. Popular destinations include resort areas along the Black Sea, the Baltic Sea, and the Volga River, and in Siberia. However, price increases and ethnic unrest have made holidays away from home less appealing.

Religion. The Soviet Union was hostile to religion. But religion played an important role in the lives of many of the country's people. In the late 1980's, religious toleration began to increase dramatically. Churches recovered property seized by the Soviet government. Thousands of new parishes opened. Church attendance shot up. Sunday schools opened across the country, and churches took part in charity work. Publication of religious literature resumed, and new seminaries opened. The celebration of Russian Orthodox Christmas on January 7 was made a national holiday.

The Russian Orthodox Church is the largest religious denomination in Russia. Other important religious groups in the country include Muslims; Baptists, Pentecostalists, and other Protestant denominations; Roman Catholics; and Jews.

Education. The Soviet government controlled education and considered it a major vehicle of social advancement. As a result, almost all Russians can read and write. Today, public education in Russia remains free for all citizens. New private schools are also opening. The Soviet government had banned such schools.

Russian educators are changing the school curriculum to better prepare students for the new economy. They are working to remove the influence of Communist Party ideology. Educators are also trying to better satisfy the interests of Russia's nationality groups.

All children attend school for 11 years, from age 6 to 17. Elementary education includes nine primary and intermediate grades. When pupils finish ninth grade, they may choose to complete their schooling by enrolling in a secondary school or vocational school. The secondary schools emphasize science and mathematics. They also teach language, literature, history, social sciences, and physical education. English is the most widely taught foreign language. The vocational schools prepare young people for careers as technicians or in various branches of industry and agriculture.

Starting with the intermediate grades, pupils must pass annual exams to advance to the next grade. Students who pass a national examination upon the completion of secondary school receive a certificate, and those who score well also receive a gold or silver medal. Schools use a number grading scale of 1 to 5, with 5 being the highest.

Many gifted children attend special schools. These schools stress individual subjects such as mathematics or physics, languages, or the arts. Russia also has schools for children with physical or learning disabilities.

Students must pass an entrance exam to be admitted to a university or institute of higher education. Russia has 500 institutions of higher education equivalent to colleges and universities, with about 3 million students. Moscow State University, the largest university in Russia, has 28,000 students.

Museums and libraries. The people of Russia spend more time in museums than do the people of most industrial countries. Russia has more than 660 museums. The State Historical Museum in Moscow is the country's chief historical museum. Several museums dealing

Soccer is the most popular sport in Russia, among both participants and spectators. Russia has many sports camps and clubs, recreational centres, and other athletic facilities for children and adults.

with the history of the Russian Revolution. These museums include the Central Museum of the Revolution, which is located in Moscow. The Hermitage Museum in St. Petersburg has one of the world's largest art collections.

Russia has about 62,000 libraries. Most towns and large villages have a public library. There are also libraries specializing in particular subjects and libraries run by factories, schools, trade unions, and professional and civic organizations. The Russian State Library in Moscow is the largest library in Russia. Other major libraries in Moscow include the All-Russian State Library of Foreign Literature, INION (Institute of Scholarly Information for the Social Sciences of the Academy of Sciences), the State Historical Library, and the Gorki Library at Moscow State University. St. Petersburg is home to the Saltykov-Shchedrin State Library and the Library of the Russian Academy of Sciences.

Arts

The arts in Russia date back to the earliest days of the country. But Russian artists did not produce internationally recognized works in many fields until the early 1800's. Throughout much of the 1800's and the early 1900's, Russia became an international leader in classical music, ballet, drama, and literature. Several Russian painters and sculptors also gained worldwide fame.

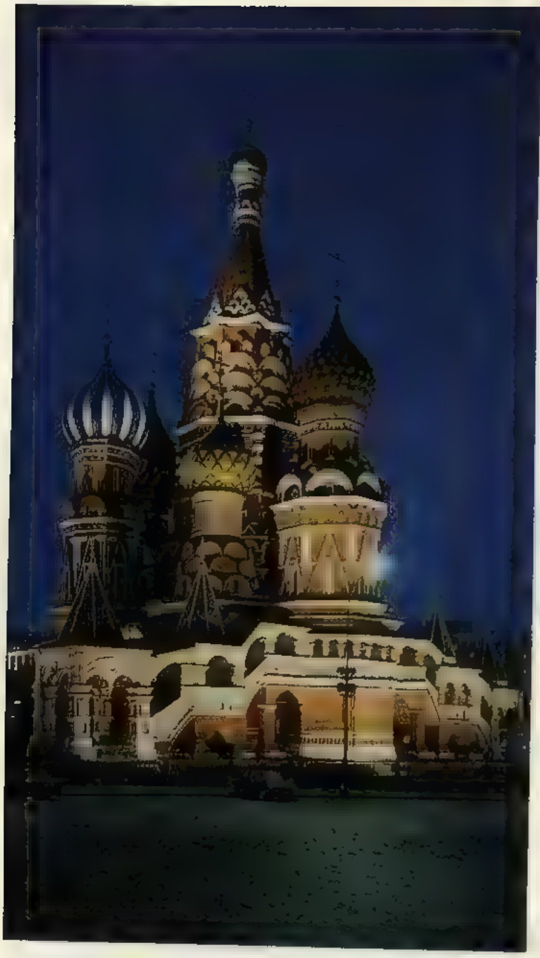
This section discusses Russian architecture, music, ballet, painting, and sculpture. For information on Russian drama and literature, see **Russian literature** with its list of *Related articles.*

Architecture in Russia has been shaped by religious and Western influences combined with local traditions. In 988, Grand Prince Vladimir I, ruler of the state of Kievan Rus, was converted to the Byzantine (Eastern Orthodox Christian) faith. For hundreds of years, Russian architecture reflected the influence of the Byzantine style. The most important structures were churches, which had distinctive onion-shaped domes. The best-known Byzantine church is St. Basil's Cathedral in Moscow, built by the first czar, Ivan IV (also called Ivan the Terrible), from 1555 to 1560. See **Byzantine art.**

In 1682, Peter I, also known as Peter the Great, became czar. Peter introduced Western European artistic styles into Russia. He founded the city of St. Petersburg in 1703 and brought Western European architects and artists to help design it. Many of the buildings dating from his reign and through the mid-1700's were designed in the Western European baroque style by Italian and French architects. A famous example is the Great Palace at Peterhof (now Petrodvorets).

Among the most widely recognized architectural works in Russia are the buildings within the enclosed fortress in Moscow called the Kremlin. The Kremlin includes churches, palaces, and other buildings erected from the late 1400's to the mid-1900's. Some Kremlin buildings house Russia's government, and others serve as museums. See **Kremlin.**

Music. Until the mid-1700's, Russian music consisted almost entirely of vocal music sung in church worship services and of folk music, which was also mainly vocal. Nonreligious music began to flower during the reign of Elizabeth, the empress of Russia from 1741 to 1762. She established the Academy of Arts in 1757, which taught music. Italian opera became popular during her reign. The popularity of music in Russia expanded further during the reign of Catherine II, known as Catherine the Great, who ruled from 1762 to 1796. The earliest written collection of Russian folk songs appeared in four volumes published between 1776 and 1795.



St. Basil's Cathedral in Moscow has colourful onion-shaped domes that have made it one of the most widely recognized buildings in Russia. The Byzantine-style cathedral was built from 1555 to 1560 by Ivan the Terrible, Russia's first czar.

The Trinity by Andrei Rublev, Tretyakov Gallery, Moscow

Religious paintings called *icons* dominated Russian art from the late 900's to the late 1600's. Icons were created for Russian Orthodox worship services and were considered sacred.

Mikhail Glinka is credited with founding a distinctively Russian school of classical music in the early and middle 1800's. He blended folk songs and religious music into his works and also introduced subjects from Russian history. Glinka's most influential work is probably his second opera, *Ruslan and Lyudmila* (1842), based on a fairy tale written by the Russian poet Alexander Pushkin.

By the late 1800's, Russian music flourished. Such composers as Modest Mussorgsky, Nikolai Rimsky-Korsakov, Peter Ilich Tchaikovsky, and Alexander Borodin wrote operas and instrumental music. Much of their work was based on Russian history and folklore. In the early 1900's, Sergei Rachmaninoff and Igor Stravinsky gained international fame for their musical compositions. Stravinsky wrote several influential ballet scores, including *The Firebird* (1910), *Petrouchka* (1911), and *The Rite of Spring* (1913). See the list of Russian composers in the *Related articles* section of **Classical music.**

Ballet. Russian ballet became internationally famous starting in the mid-1800's. The leading ballet companies, which continue to perform today, are the Kirov Ballet (formerly the Russian Imperial Ballet) of St. Petersburg and the Bolshoi Theatre Ballet of Moscow. See **Ballet** (Russian ballet); **Bolshoi Theatre Ballet.**

Painting and sculpture. Until the early 1900's, the most important Russian paintings were created for religious purposes. Russian artists decorated the interiors of churches with wallpaintings and mosaics. Stylized paintings called *icons* were produced for many centuries. An icon is a religious painting considered sacred in Eastern Orthodox Christianity. Icons were produced according to strict rules established by the church, and their style changed little over the years. See **Icon.**

By the mid-1800's, Moscow and St. Petersburg had busy art schools. Russian artists also began to create paintings and sculptures on more varied subjects.

A burst of creativity in Russian art exploded during the years before the start of World War I in 1914. Russian artists were strongly influenced by the modern art movements emerging in Western Europe. The painters Marc Chagall, Alexei von Jawlensky, and Wassily Kandinsky eventually settled in Western Europe.

Artists who remained in Russia developed two important modern art movements, *suprematism* and *constructivism.* Both movements produced paintings that were *abstract*—that is, they had no recognizable subject matter. The leading suprematist was Kasimir Malevich. The major constructivists included Naum Gabo, Antoine Pevsner, and Vladimir Tatlin. See **Chagall, Marc; Gabo, Naum; Kandinsky, Wassily; Pevsner, Antoine.**

The East Siberian Uplands are mainly a wilderness of mountains and plateaus. The region has valuable mineral resources, but its harsh climate makes it difficult to use them. Small towns, such as the one shown above, are sparsely scattered throughout the East Siberian Uplands.

Land and climate

Russia is the largest country in the world. It has an area of 17,075,400 square kilometres, almost twice that of Canada, the second largest country. A train trip between Moscow in the west and Vladivostok in the east takes seven days and passes through eight time zones.

Land regions

Many scientists divide Russia into four zones according to soil conditions and plant life, which are based

A belt of rich farmland stretches across Russia from east to west. In the photograph on the left, farmworkers harvest wheat on the European Plain. This mainly flat landform makes up most of the European part of Russia.

Physical features

Sikhote-Alin Range (mountains)	F	11
Stanovoy Range (mountains)	E	10
Stanovoy Upland	F	9
Stony Tunguska River	E	7
Sukhona River	D	3
Suntar Khayata Mountains	D	10
Syverma Plateau	D	7
Tatar Strait	E	11
Tavda River	E	4
Taymyr Lake	C	7
Taymyr Peninsula	C	7
Taz River	E	6
Tazovskaya Bay	D	6
Tobol River	E	4
Tsimlyansk Reservoir	E	2
Udskaya Bay	E	11
Ural River	F	3
Ussuri River	F	11
Valdai Hills	D	2
Vasyuganye (marshes)	E	5
Verkhoyansk Range (mountains)	D	9
Vilkitski Strait	C	7
Vilyuy Range (mountains)	D	8
Vilyuy Reservoir	E	8
Vilyuy River	D	9
Vitim River	F	9
Volga River	F	2
Volga Upland	E	2
Volga-Don Canal	F	2
Volgograd Reservoir	E	2
White Sea	C	3
White Sea-Baltic Canal	C	3
Wrangel Island	A	10
Yablonovyy Range (mountains)	F	9
Yamal Peninsula	C	5
Yana River	C	9
Yanskiy Gulf	C	9
Yenisey Gulf	C	6
Yenisey Range (mountains)	E	6
Yenisey River	D	6
Zeya Reservoir	F	10
Zeya River	F	10

mainly on climate. The zones form broad belts across Russia, and no sharp transitions separate them. From north to south, the zones are (1) the tundra, (2) the forest zone, (3) the steppes, and (4) the semidesert and mountainous zone.

The tundra lies in the northernmost part of Russia. It is largely a treeless plain. The tundra has short summers and long, severe winters. About half the region has permanently frozen soil called *permafrost.* Few people live in this bleak area. Plant life consists chiefly of low shrubs, dwarf trees, and moss. Animals of the tundra include reindeer, arctic foxes, ermines, hares, and lemmings. Waterfowl live near the Arctic Sea in summer.

The forest belt lies south of the tundra. The northern part of this belt is called the *taiga.* It consists of *coniferous* (cone-bearing) trees, such as cedar, fir, pine, and spruce. This area has poor, ashy soil, known as *podzol,* that makes it largely unfit for agriculture. Farther south, the coniferous forests give way to mixed forests of conifers, aspen, birch, elm, maple, oak, and other species. The soils in this zone support agriculture in some areas, and the area has a mild, moist climate. Brown bears, deer, elk, lynx, reindeer, and smaller animals such as beavers, rabbits, and squirrels roam the forests.

Grassy plains called *steppes* stretch across Russia south of the forests. The northern part of the steppe zone consists of wooded plains and meadows. The massive southern part is largely a treeless prairie. The best soils in Russia—brown soil and black, rich soil called *chernozem*—are found there. Most of the steppe zone is farmland. Birds, squirrels, and mouselike mammals called *jerboas* live in the steppes. Antelope live in the eastern steppes.

The semidesert and mountainous zone, the southernmost zone in Russia, has diverse soils and climate due to variations in elevation. It includes the dry, semidesert lowlands near the Caspian Sea, as well as the lush vegetation and mild climate of the Caucasus Mountains.

Geologists also divide Russia into five land regions that differ from the soil and vegetation zones. From west to east, the regions are (1) the European Plain, (2) the Ural Mountains, (3) the West Siberian Plain, (4) the Central Siberian Plateau, and (5) the East Siberian Uplands.

The European Plain makes up most of the European part of Russia. It is the most densely populated region in the country. The European Plain is predominantly flat to gently rolling, averaging about 180 metres above sea level. Most of the nation's industries are there, but the plain is poor in natural resources. Forest covers much of it. The region is home to a variety of animal life. The Caucasus Mountains rise at the southern edge of the plain, between the Black and the Caspian seas. The mountains include 5,642-metre Mount Elbrus, the highest point in Europe.

The Ural Mountains form the traditional boundary between the European and Asian parts of Russia. These mountains, worn down by streams, reach an average height of only about 610 metres. The middle and southern Ural Mountains are rich in deposits of iron, copper, and other metals. The middle section is the most heavily populated and highly industrialized area. Major cities in the region include Yekaterinburg and Chelyabinsk.

The West Siberian Plain is the largest level region in the world. This enormous plain covers more than 2.6

million square kilometres and rises no more than 150 metres above sea level. It is drained by the Ob River system, which flows northward into the Arctic Ocean. But drainage is poor, and the plain is marshy. Rich in oil and natural gas deposits, the West Siberian Plain is being developed rapidly. The cities of Novosibirsk and Omsk lie in the region.

The Central Siberian Plateau slopes upward toward the south from coastal plains along the Arctic Ocean. It has an average height of about 610 metres. Streams cut deeply through the region. The Sayan and Baikal mountains rise more than 3,350 metres along the plateau's southern edge. Thick pine forests cover much of the Central Siberian Plateau, and its climate reaches extremes of heat and cold. The region has a wide variety of rich mineral deposits. Krasnoyarsk and Irkutsk are its largest cities.

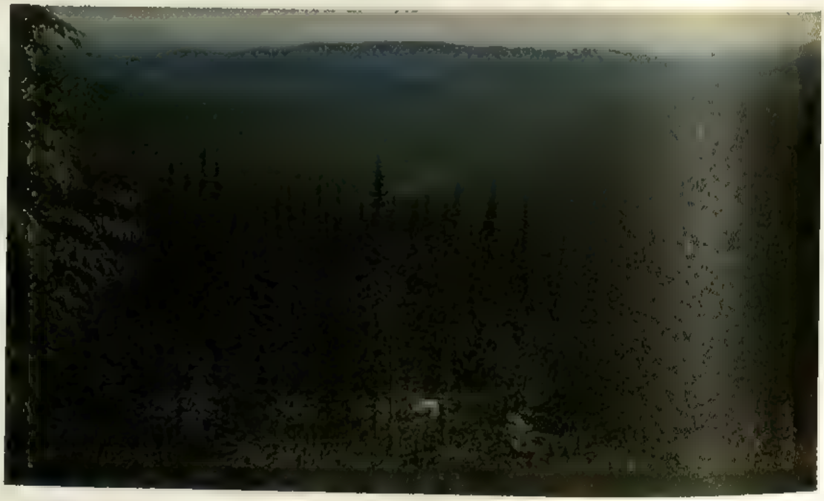
The East Siberian Uplands are mainly a wilderness of mountains and plateaus. The mountains rise to 3,000 metres and form part of a series of ranges along the eastern coast of Asia and some offshore islands. About 25 active volcanoes are found on the Kamchatka Peninsula. The tallest volcano, snow-capped Klyuchevskaya, rises 4,750 metres. The region has valuable mineral resources, but its harsh climate makes it difficult to tap them. Vladivostok on the Pacific Ocean and Khabarovsk on the Amur River are the region's most important cities.

Rivers and lakes

Russia's many large rivers have served as important means of communication and commerce. The construction of canals further improved these activities.

The Lena River in Siberia, 4,400 kilometres long, is the longest river in Russia. It empties into the Arctic Ocean. Other major rivers in Siberia include the Amur, Ob, and Yenisey rivers, all frozen seven to nine months a year. The Volga River is the longest river in European Russia. The river originates in the Valdai Hills northwest of Moscow and flows 3,531 kilometres to the Caspian Sea. The Volga freezes for about three months each year. The Don and Northern Dvina rivers are also in European Russia.

Russia has about 200,000 lakes. The Caspian Sea, a saltwater lake 28 metres below sea level, is the world's largest inland body of water. It touches the southern part of European Russia. Lake Ladoga, near St. Petersburg, covers 17,703 square kilometres. It is the largest lake entirely in Europe. Lake Baikal, near the Baikal Mountains, is the deepest lake in the world. It plunges 1,620 metres deep.



A thick forest blankets the northern part of Russia from Europe to the Pacific Ocean. It covers much of Siberia. Few people live in this vast area.

Lake Baikal, the deepest lake in the world, lies in Siberia. It has a depth of 1,620 metres. A small community, *right,* is nestled between Lake Baikal and the surrounding mountains.

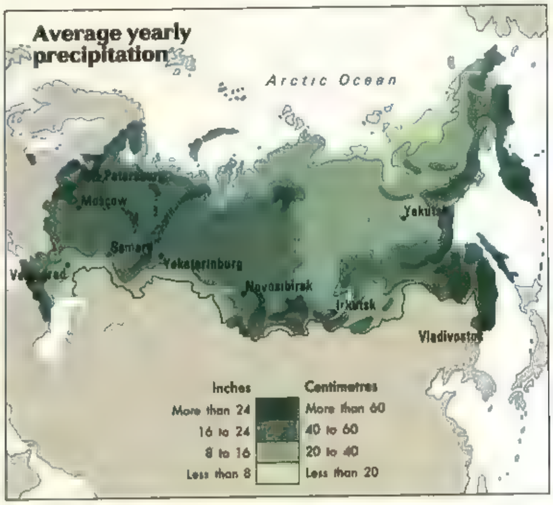
Climate

Russia is known for its long and bitter winters. The country's hostile climate helped stop various invaders during its history, including the large armies of Napoleon in 1812 and of Adolf Hitler in 1941 and 1942. In the Moscow region, snow covers the ground for about five months each year. In the northernmost part of Russia, snow abounds for eight to nine months a year. The small percentage of Russia's land that is fit for agriculture has a short growing season and insufficient rainfall. Half the land has permafrost beneath the surface. Most of the coastal waters, lakes, and rivers freeze for much of the year.

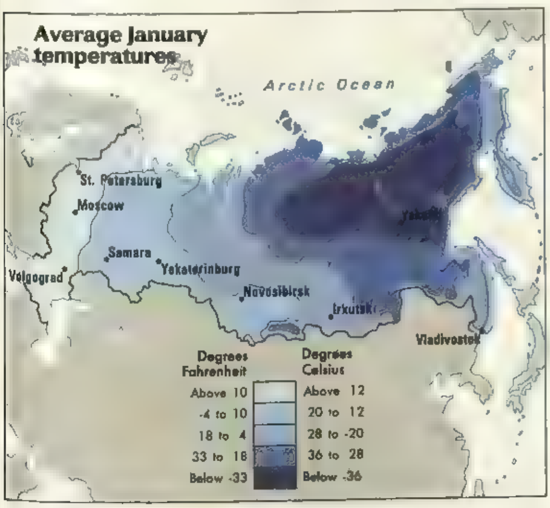
Russia's weather varies from extremely cold to extremely hot. Northeastern Siberia is one of the coldest regions in the world. January temperatures there average below −46 °C. Temperatures as low as −68 °C have been recorded. The average July temperature in this region is 16 °C, but it can climb to nearly 38 °C. No other part of the world registers such a wide range of temperatures.

Precipitation (rain, melted snow, and other forms of moisture) is light to moderate. The European Plain and parts of the East Siberian Uplands receive the most rain. Vast inland areas get little rain. The heaviest snowfalls—up to 120 centimetres of snow a year—occur in western and central Siberia.

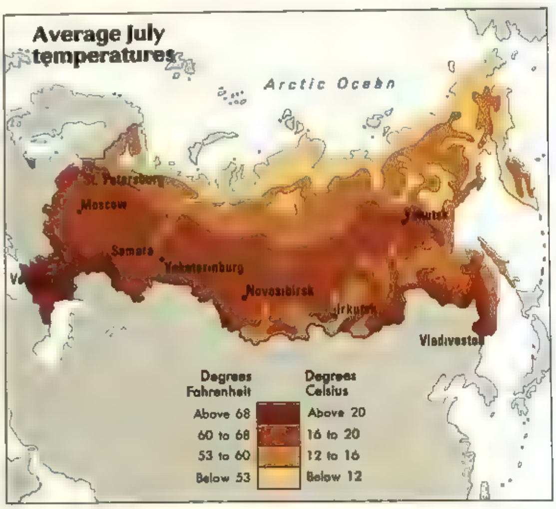
Winters are long and cold in most parts of Russia. Snow covers the ground in the Moscow region for about five months each year. This photograph shows a Moscow street in winter.



Rainfall in Russia is heaviest on the European Plain, in parts of the East Siberian Uplands, and in mountainous regions along the southern border. Vast areas of the interior get little rain.



January temperatures in eastern Siberia are among the coldest in the world, dropping as low as −68 °C. January temperatures in Russia average above −12 °C only in the westernmost part of the country.



July temperatures in Russia vary widely. Most of the country has an average July temperature above 16 °C, but temperatures can hit almost 38 °C in northeastern Siberia and drop below 0 °C on islands in the Arctic Ocean.

Economy

In the Soviet Union, central government agencies planned almost all aspects of the economy. The government owned and controlled all factories and farms, and private businesses were illegal. Soviet leaders changed Russia from a farming country into an industrial giant. Heavy industry—such as chemicals, construction, machine tools, and steel—developed rapidly. Government ministries supplied factories with materials, set production quotas, and told managers what to produce and to whom to sell their goods. This planning led to rapid industrial development and impressive economic gains. But once the economy developed, central control began to suppress new ideas and discourage quality.

Russia inherited the successes and problems of the former Soviet Union's industrial policy. The Russian government is working to convert state-owned property, including large factories and farms, to private ownership. Many small businesses and joint ventures with foreign partners have started. Russia turned to Western countries and Japan for assistance in modernizing and restructuring its manufacturing sector.

When the Soviet Union collapsed, the economy was in a state of disarray. To stabilize the Russian economy, reduce inflation, and attract foreign investment, the government plans to allow the conversion of the rouble into other forms of currency. This will enable it to be exchanged for other currencies at international rates. The Russian government has also begun to set up a modern banking system. The government lifted price controls on most items in 1992, and prices soared. At that time, most people's incomes remained near previous levels, putting many items out of their reach. Though incomes have risen gradually in the mid-1990's, most Russians have not yet reached the standard of living that they had before the collapse of the Soviet Union.

The Russian government's bold break from past Soviet economic policies caused great instability in the early and mid-1990's. Industrial output fell, and inflation rose dramatically. The links between economy and government that existed in the Soviet Union had broken down, but new institutions had not yet replaced them.

On the positive side, Russia has a skilled labour force and an abundance of natural resources. Many new businesses have been started throughout the country, and about two-thirds of the state-owned businesses were privatized by the mid-1990's.

Natural resources. Russia is one of the richest countries in terms of natural resources. It has the world's largest forest reserves, enormous energy supplies, vast stretches of farmland, extensive mineral deposits, and many potential sources of hydroelectric power. Russia also has a wide variety of plant and animal life.

Manufacturing. Heavy industry is the most highly developed sector of the Russian economy. The machine-building industry is concentrated in Moscow and St. Petersburg, along the Volga River, and in the Ural Mountains. It makes various types of tractors and other heavy machinery and electrical equipment. The chemical industry produces chemical fibres, mineral fertilizers, petrochemicals, plastics, soda ash, and synthetic resins. The construction materials industry is also important.

The Moscow area is Russia's leading manufacturing centre. Its factories produce chemicals, electrical equipment, electronics, motor vehicles, processed foods, steel, and textiles. Ships and industrial equipment are manufactured in St. Petersburg. Metal processing and machinery production are important in the Urals. Most oil refining takes place in the Volga-Urals region. New industries are being developed in Siberia to make use of the region's mineral and hydroelectric resources. Light industry, particularly textile production, is centred in the region around Moscow and along the Volga River. The paper industry operates along the southern edge of the forest belt.

Agriculture. Russia has a large amount of farmland. But a short growing season, insufficient rainfall, and a lack of fertile soil make farming difficult. The Soviet Union's inefficient system of state-run farms added to Russia's agricultural problems.

There are about 15,000 large, state-controlled farms in Russia. About half are state farms operated like government factories, called *sovkhozy.* Workers on sovkhozy receive wages. The rest are collective farms called *kolkhozy,* which are government-controlled but managed in part by farmers.

By the mid-1990's, over 260,000 private farms had been established. But these farms included only a tiny percentage of Russia's farmland. New laws called for the breakup of unprofitable government farms and for more aid to independent farmers. Nevertheless, the transition to private farms proved to be slow and difficult.

Approximately 13 per cent of Russia's land is cropland. One of the main agricultural regions is the Black Earth Belt, a portion of the steppes stretching from the

Collective farms called *kolkhozy* are controlled by the Russian government but managed in part by farmers. This photograph shows a potato harvest at one such farm.

Manufacturing is an important economic activity in Russia. Many of the country's metal-processing and machine-building plants, such as the steel mill on the left, are in the Ural Mountains region.

Economy of Russia

This map shows the major uses of land in Russia. The map also shows where the leading farm, fishing, mineral, and forest products are produced, and it locates the chief manufacturing centres.

Wheat-growing land
Other cropland
Mostly grazing land
Forest land
Tundra or mountainous area
Fishing
Manufacturing centre
Mineral deposit

Long pipelines, such as the one shown above, transport natural gas from fields in Siberia to European Russia. The gas is burned to provide energy for industry and heat for homes. It is also a natural resource for the production of certain chemicals.

Ukrainian border to southwestern Siberia that is famous for its dark chernozem soil. Other important farming regions are the Volga area, the northern Caucasus Mountains, and western Siberia. Russia is one of the world's major grain producers. However, the country still must import grain for food. Major crops grown in Russia include barley, flax, fruit, oats, potatoes, rye, sugar beet, sunflowers, vegetables, and wheat. Russian farmers also grow many *fodder crops*—that is, food crops for animals. Grasses and corn are the most important fodder crops.

Livestock breeding is another main component of Russian agriculture. Cattle, pigs, and sheep are the most important livestock raised in the country.

Mining. Russia has vast amounts of most of the minerals used in modern industrial production. The country has abundant coal deposits and huge reserves of petroleum and natural gas. Other resources include calcium phosphate minerals and phosphorites, used in fertilizers, and diamonds.

Russia is a major producer of iron ore, manganese, nickel, and the platinum-group metals, a group of rare metals including platinum and iridium. Nickel is mined in the Kola Peninsula, eastern Siberia, and the southern Urals. Platinum is mined in the Urals and in northern Siberia. The country ranks as a leading producer of gold, lead, salt, tin, tungsten, and zinc. It is also an important source of copper and silver. Bauxite, a mineral used in making aluminium, is mined in western Siberia.

Fishing industry. In the northern Barents Sea and the White Sea, Russian fishing crews catch cod, had-

A fishing crew brings in sturgeon from the mouth of the Volga River. Sturgeon eggs are used to make *caviar,* a salty delicacy. Russia is famous for its flavourful caviar.

Railways transport freight and passengers between Russia's major cities, many of which are separated by vast distances. The photograph on the left shows a train on the Trans-Siberian Railway, which runs between Vladivostok in the southeast and Moscow in the west.

dock, herring, salmon, and other fish. Sturgeon are caught in the Caspian Sea. *Caviar,* the salted eggs of sturgeon, is a famous Russian delicacy. Crews also fish in inland waterways, the Atlantic and Pacific oceans, and the Baltic and Black seas.

Service industries are industries that produce services, not goods. In the former Soviet Union, these industries were underdeveloped. Most service-industry workers were poorly trained and underpaid. They had little incentive to satisfy their customers, who competed for services that were in short supply.

Today, private economic activity in the service sector is flourishing. Many individuals and families are starting small businesses such as restaurants, barbershops, dry cleaners, and taxi services.

Energy sources. Russia has enormous natural energy reserves, especially petroleum and natural gas. The country is the world's largest producer of crude oil. Oil fields in western Siberia supply more than half of Russia's petroleum. The Volga-Ural Oil-Gas Region, the Northern Caucasus, and the Timan-Pechora Oil-Gas Basin are also important. Russia also produces large amounts of coal and natural gas. Pipelines carry oil and natural gas from western Siberia to European Russia. The country's largest coal mines lie in the Kuznetsk and Pechora basins. Peat bogs also furnish some fuel.

Most of Russia's electric power plants are steam-turbine plants. Huge hydroelectric plants also generate electricity. Russia also ranks as a major producer of nuclear power.

Trade. The Soviet Union traded mainly with Communist Eastern European countries such as Hungary, and Poland. Since the overthrow of the Communist regimes of Eastern Europe and the breakup of the Soviet Union, Russia's trading activity with those countries has declined. Russia's main trading partners today are the other former Soviet republics, the Czech Republic, France, Germany, Italy, Japan, and the United States. Trade with some developing nonsocialist countries, such as Syria and Turkey, has increased. In addition, Russia exchanges goods with Cuba and Finland.

Russia exports mostly petroleum, natural gas, minerals, machinery, chemicals, and wood and paper products. Its major imports include consumer goods, industrial equipment, foods and beverages, and machinery.

Transportation and communication. Because of Russia's vast size and harsh climate, transportation facilities and communications systems are unevenly distributed throughout the country. They are less efficient than the transportation and communications networks of Western Europe, the United States, and Japan.

Railways handle most freight transportation in Russia. But the system is heavily loaded and in urgent need of modernization. Russia's poorly developed road network, combined with the country's vast size, make truck transport ineffective and costly. It makes up only about 5 per cent of total freight movement. River transportation carries only a small percentage of Russia's freight traffic, because most rivers are frozen for much of the year. Canals such as the Volga-Don Canal and the Moscow Canal, which connects Moscow with the Volga River, make an important contribution to river traffic.

Aeroflot is Russia's national airline. It had been the national airline of the Soviet Union. Aeroflot carries freight and passengers between all major Russian cities and between Russia and many other countries. Fuel shortages and rising ticket costs have reduced air traffic.

Russia's most important seaports—Arkhangelsk, Kaliningrad, Murmansk, Nakhodka, St. Petersburg, and Vladivostok—handle a large portion of the country's foreign trade. However, the water at many Russian ports is frozen for many months of the year.

Car production is increasing in Russia, but it remains small in comparison with other industrial nations. Only about 56 of every 1,000 Russians own cars. It is difficult for car owners to obtain servicing and spare parts nationwide.

Public transportation is modern and inexpensive, but crowded. Several large cities, including Moscow, have clean, efficient underground railway systems. Buses, trams, and trolleys also operate in the cities. Bicycles are seen in large cities, but they are more common in rural and holiday areas. Horse-drawn carriages can also be found in rural parts of Russia.

Russia has an underdeveloped telecommunications system. It takes years to install telephones in new apartment complexes.

During most of the history of the Soviet Union, the government controlled all communications media, including broadcasting, film production, and publishing. The government required all broadcasts and publications to follow Communist Party policies. Such censorship began to ease in the late 1980's, and it no longer exists in Russia. As a result, the number of independent newspapers and publishing houses has increased dramatically. Most families own radios and television sets. Videocassette recorders are in great demand, but they are expensive and hard to find.

History

Russia's unique geographic location astride both Europe and Asia has influenced its history and shaped its destiny. Russia never has been entirely an Eastern or a Western country. As a result, Russian intellectuals have long debated the country's development and contribution to world history.

This section traces the major developments of Russian history. In 1917, revolutionaries overthrew the Russian czarist government. They changed Russia's name to the Russian Soviet Federative Socialist Republic (R.S.F.S.R.). In 1922, the R.S.F.S.R. and three other republics formed a new nation called the Union of Soviet Socialist Republics (U.S.S.R.), also known as the Soviet Union. The U.S.S.R. broke apart in 1991, and Belarus, Russia, and Ukraine invited the other republics to join a federation called the Commonwealth of Independent States. For more detailed information about this period, see **Union of Soviet Socialist Republics** (History).

Early days. Beginning about 1200 B.C., the Cimmerians, a Balkan people, lived north of the Black Sea in what is now southern Ukraine. They were defeated about 700 B.C. by the Scythians, an Iranian people from central Asia. The Scythians controlled the region until about 200 B.C. They fell to the Sarmatians, another Iranian group. The Scythians and the Sarmatians lived in close contact with Greek colonies—later controlled by the Romans—along the northern coast of the Black Sea. They absorbed many Greek and Roman ways of life through trade, marriage, and other contacts. See **Cimmerians.**

Germanic tribes from the West, called the Goths, conquered the region about A.D. 200. The Goths ruled until about 370, when they were defeated by the Huns, a warlike Asian people. The Huns' empire broke up after their leader, Attila, died in 453. The Avars, a tribe related to the Huns, began to rule the region in the mid-500's. The Khazars, another Asian people, won the southern Volga and northern Caucasus regions in the mid-600's. They became Jews and established a busy trade with other peoples. See **Goths; Hun.**

By the 800's, Slavic groups had built many towns in eastern Europe, including what became the European part of Russia. They had also developed an active trade. No one knows where the Slavs came from. Some historians believe they came in the 400's from what is now Poland. Others think the Slavs were farmers in the Black Sea region under Scythian rule or earlier. Slavs of what are now Belarus, Russia, and Ukraine became known as East Slavs. See **Slavs.**

The earliest written Russian history of the 800's is the *Primary Chronicle,* written in Kiev, Ukraine, probably in 1111. It says that quarrelling Slavic groups in the town of Novgorod asked a Viking tribe to rule them and bring order to the land. The Vikings were called the *Varangian Russes.* Historians who accept the *Primary Chronicle* as true believe that Russia took its name from this tribe. According to the *Primary Chronicle,* a group of related Varangian families headed by Rurik arrived in 862. Rurik settled in Novgorod, and the area became known as the "land of the Rus."

Many historians doubt that the Slavs of Novgorod invited the Vikings to rule them. They believe the Vikings invaded the region. Some historians claim the word *Rus,* from which Russia took its name, was the name of an early Slavic tribe in the Black Sea region. It is known,

Important dates in Russia

A.D. 800's East Slavs established the state of Kievan Rus.
1237-1240 The Mongols conquered Russia.
c. 1318 The Mongols appointed Prince Yuri of Moscow as the Russian grand prince.
1480 Ivan III broke Mongol control over Russia.
1547 Ivan IV became the first Russian czar.
1604-1613 Russia was torn by civil war, invasion, and political confusion during the Time of Troubles.
1613 Michael Romanov became czar. He started the Romanov line of czars, which ruled until 1917.
1703 Peter I founded St. Petersburg and began building his capital there.
1812 Napoleon invaded Russia. He was forced to retreat.
1861 Alexander II freed the serfs.
1905 Japan defeated Russia in the Russo-Japanese War. A revolution forced Nicholas II to establish a parliament.
1914-1917 Russia fought Germany and Austria-Hungary in World War I.
1917 The February Revolution overthrew Nicholas II. The Bolsheviks (later called Communists) seized power in the October Revolution. V. I. Lenin became head of government. Russia withdrew from World War I.
1918-1920 The Communists defeated their anti-Communist opponents in a civil war.
1922 The U.S.S.R. was established.
1991 Communist rule ended, and the republics declared their independence. The Soviet Union was dissolved on December 25.
1993 President Boris Yeltsin dissolved parliament after parliament blocked his reform policies.

however, that the first state founded by East Slavs—called Kievan Rus—was established at present-day Kiev in the 800's. Kiev, now the capital of Ukraine, was an important trading centre on the Dnepr River. Whether it had been developed by the Vikings is unclear.

The state of Kievan Rus. The *Primary Chronicle* states that Oleg, a Varangian, captured Kiev in 882 and ruled as its prince. During the 900's, the other *principalities* (regions ruled by a prince) of Kievan Rus recognized Kiev's major importance. Kiev lay on the main trade route connecting the Baltic Sea with the Black Sea and the Byzantine Empire. In addition, Kiev's forces defended Kievan Rus against invading tribes from the south and east. The ruler of Kiev came to be called *grand prince* and ranked above the other princes of Kievan Rus.

In 988, Grand Prince Vladimir I (*Volodymyr* in Ukrainian) became a Christian. At that time, the East Slavs worshipped the forces of nature. Vladimir made Christianity the state religion, and most people under his rule turned Christian. Vladimir later became a saint of the Russian Orthodox Church.

Several grand princes were strong rulers, but Kiev's power began to decrease after the mid-1000's. The rulers of other Kievan Rus principalities grew in power, and they fought many destructive wars. In Novgorod and a few other towns with strong local governments, the princes were driven out. Badly weakened by civil wars and without strong central control, Kievan Rus fell to huge armies of Mongols called *Tatars*, or *Tartars*, who swept across Russia from the east during the 1200's (see Tatars).

Mongol rule. In 1237, Batu, a grandson of the conqueror Genghis Khan, led between 150,000 and 200,000 Mongol troops into Russia. The Mongols destroyed one Russian town after another. In 1240, they destroyed Kiev, and Russia became part of the Mongol Empire. It was included in a section called the Golden Horde. The capital of the Golden Horde was at Sarai, near what is now Volgograd. See **Mongol Empire**.

Illustration from a Russian manuscript of the 1500's; Russian State Library, Moscow

The Battle of Kulikovo in 1380 was the first Russian victory over the Mongol forces. It took place near the Don River.

Batu forced the surviving Russian princes to pledge allegiance to the Golden Horde and to pay heavy taxes. From time to time, the Mongols left their capital and wiped out the people of various areas because of their disloyalty. The Mongols also appointed the Russian grand prince and forced many Russians to serve in their armies. But they interfered little with Russian life in general. The Mongols were chiefly interested in maintaining their power and collecting taxes.

During the period of Mongol rule, which ended in the late 1400's, the new ideas and reforming spirit of the Renaissance were dramatically changing many aspects of life in Western Europe. But under Mongol control, Russia was cut off from these important Western influences.

The rise of Moscow. In the early 1300's, Prince Yuri of Moscow married the sister of the Golden Horde's *khan* (ruler). Yuri was appointed the Russian grand prince about 1318. Mongol troops helped him put down threats to his leadership from other principalities. The Mongols also began letting the grand prince of Moscow collect taxes for them. This practice started with Ivan I (called the Moneybag) about 1330. Ivan kept some of the tax money. He bought much land and expanded his territory greatly. Other princes and *boyars* (high-ranking landowners) began to serve in Moscow's army and government. In addition, Ivan persuaded the chief bishop of the Russian Orthodox Church to remain in Moscow. Until then, Kiev had been the spiritual centre of Russia.

Moscow grew stronger and richer. But the Golden Horde grew weaker, chiefly because of struggles for leadership. In 1380, Grand Prince Dmitri defeated a Mongol force in the Battle of Kulikovo, near the Don River. The victory briefly freed Moscow of Mongol control. The Mongols recaptured Moscow in 1382, but they no longer believed they could not be beaten.

During the late 1400's, Moscow became the most powerful Russian city. Ivan III (called Ivan the Great) won control of Moscow's main rivals, Novgorod and Tver, and great numbers of boyars entered his service. In 1480, Ivan made the final break from Mongol control by refusing to pay taxes to the Golden Horde. Mongol troops moved toward Moscow but turned back to defend their capital from Russian attack.

Ivan the Terrible. After the rise of Moscow, its grand prince came to be called *czar*. In 1547, Ivan IV, also known as Ivan the Terrible, became the first ruler to be crowned czar. Ivan made the power of the czar over all Russia complete.

Ivan was brutal, extremely suspicious, and perhaps, at times, insane. He formed a special police force and began a reign of terror in which he ordered the arrest and murder of hundreds of aristocrats. Ivan gave his victims' estates as payment to the *service gentry* (landowners serving in the army and government). He also established strict rules concerning the number of warriors and horses each landowner had to supply to the army. Ivan burned many towns and villages, and he killed church leaders who opposed him. In a fit of rage, Ivan even struck and killed his oldest son.

The number of service gentry increased rapidly. But their estates had no value unless the peasants remained on the land and farmed it. Ivan and later czars passed a series of laws that bound the peasants to the land as *serfs.* Serfdom became the economic basis of Russian power. The development of Russian serfdom differed sharply from changes occurring in Western Europe at the time. There, during the Renaissance, the growth of trade led to the use of money as royal payment. It also led to the disappearance of serfdom in Western Europe. See **Serf.**

Ivan fought Tatars at Astrakhan and Kazan to the southeast, and he won their lands. Russian forces then crossed the Ural Mountains and conquered western Siberia. Ivan also tried to win lands northwest to the Baltic Sea, but he was defeated by Lithuanian, Polish, and Swedish armies. See **Ivan.**

The Time of Troubles developed because of a breakdown of the czar's power after Ivan's death. Theodore I, Ivan's second son, was a weak czar. His wife's brother, Boris Godunov, became the real ruler of Russia. Theodore's younger brother, Dmitri, was found dead in 1591, and Theodore died in 1598 without leaving a male heir.

The *Zemskii Sobor* (Land Council), a kind of parliament with little power, elected Boris czar. But a man believed to be Gregory Otrepiev, a former monk, posed as Dmitri. This *False Dmitri* claimed Dmitri had not died, and he fled to Lithuania to avoid arrest. In 1604, False Dmitri invaded Russia with Polish troops. The invaders were joined by many discontented Russians. This invasion marked the beginning of the Time of Troubles. Russia was torn by civil war, invasion, and political confusion until 1613.

False Dmitri became czar in 1605, but a group of boyars killed him the next year. Prince Basil Shuisky then became czar. In 1610, Polish invaders occupied Moscow. They ruled through a powerless council of boyars until 1612. Meanwhile, a new False Dmitri and a number of other pretenders to the throne won many followers. Peasant revolts swept through Russia. Landowners and frontier people called *Cossacks* fought each other, and sometimes joined together to fight powerful aristocrats (see **Cossacks**). The Polish control of Moscow led the Russians to unite their forces and drive out the invaders. They recaptured the capital in 1612.

The early Romanovs. After the Poles were defeated, there was no one of royal birth to take the throne. In 1613, the Zemskii Sobor elected Michael Romanov czar. The Romanov czars ruled Russia for the next 300 years, until the February Revolution of 1917 ended czarist rule. See **Romanov.**

During the 1600's, Russia annexed much of Ukraine and extended its control of Siberia eastward to the Pacific Ocean. During this same period, the Russian Orthodox Church made changes in religious texts and cere-

Czars and empresses of Russia

Ruler	Reign	Ruler	Reign
* **Ivan IV**	1547-1584	**Peter II**	1727-1730
Theodore I	1584-1598	**Anne**	1730-1740
Boris Godunov	1598-1605	**Ivan VI**	1740-1741
Theodore II	1605	**Elizabeth**	1741-1762
False Dmitri	1605-1606	**Peter III**	1762
Basil Shuisky	1606-1610	* **Catherine II**	1762-1796
Michael Romanov	1613-1645	**Paul**	1796-1801
Alexis	1645-1676	* **Alexander I**	1801-1825
Theodore III	1676-1682	* **Nicholas I**	1825-1855
Ivan V	1682-1696	* **Alexander II**	1855-1881
* **Peter I**	1682-1725	* **Alexander III**	1881-1894
* **Catherine I**	1725-1727	* **Nicholas II**	1894-1917

*Has a separate article in *World Book.*

Oil painting (1885) by I. Repin; Tretyakov Gallery, Moscow

Ivan the Terrible became Russia's first czar in 1547. He expanded Russia's territory and made Moscow his capital. This painting shows Ivan after he killed his son in a fit of rage.

monies. People called *Old Believers* objected to these changes and broke away from the church. This group still follows the old practices today.

Peter the Great. In 1682, a struggle for power resulted in the crowning of two half brothers—Peter I (later known as Peter the Great) and Ivan V—as co-czars. Both were children, and Ivan's sister Sophia ruled as *regent* (temporary ruler) until Peter's followers forced her to retire in 1689. Peter made close contact with the many Western Europeans living in Moscow and absorbed much new information from them. He came into full power in 1696, when Ivan died.

Peter was greatly influenced by ideas of commerce and government then popular in Western Europe. A powerful ruler, he improved Russia's military and made many important conquests. During Peter's reign, Russia expanded its territory to the Baltic Sea in the Great Northern War with Sweden. In 1703, Peter founded St. Petersburg on the Baltic, and he moved the capital there in 1712. After travelling throughout Europe, he introduced Western-type clothing, factories, and schools in Russia, and reorganized Russia's government to make it run more efficiently.

Peter forced Russia's nobility to adopt many Western customs. He also increased the czar's power over the aristocrats, church officials, and serfs. He dealt harshly with those who opposed these changes. Under Peter, the legal status of serfs further deteriorated. See **Peter I, the Great**.

Catherine the Great. After Peter's death in 1725, a series of struggles for the throne took place. The service gentry and the leading nobles were on opposite sides. Candidates for the throne who were supported by the service gentry won most of these struggles and rewarded their followers. The rulers increased the gentry's power over the serfs and local affairs. The gentry's enforced service to the state was gradually reduced. It was ended altogether in 1762.

Magnificent royal parties and other festivities, all in the latest Western fashion, took place during the 1700's. The arts were promoted, and many new schools were started, mainly for the upper classes. The Russian Imperial School of Ballet was founded, and Italian opera and chamber music were brought to Russia. It also became fashionable in Russia to repeat the newest Western ideas on freedom and social reform, especially during the rule of Empress Catherine II, known as Catherine the Great. In 1767, Catherine called a large legislative assembly to reform Russian laws. However, the assembly achieved nothing.

Most Russians remained in extreme poverty and ignorance during this period. In 1773 and 1774, the peasants' discontent boiled over in a revolt led by Emelian Pugachev, a Cossack. The revolt swept through Russia from the Ural Mountains to the Volga River. It spread almost to Moscow before being crushed by government troops. In 1775, Catherine further tightened the landowners' control over the serfs.

Under Catherine the Great, Russia rose to new importance as a major world power. In the late 1700's, Austria, Prussia, and Russia gradually divided Poland among themselves. Russia gained nearly all of Belarus, Lithuania, and Ukraine from Poland. In wars against the Ottoman Empire (based in present-day Turkey), Russia

Peter the Great ruled Russia from 1682 until his death in 1725. Peter was a powerful ruler whose many conquests expanded Russia's empire. He also reorganized the government.

gained the Crimea and other Ottoman lands. Catherine died in 1796. She was succeeded by her son, Paul, who became czar. See **Catherine**.

Alexander I. Paul's five-year rule ended with his murder in 1801. Alexander I, Paul's son, became czar and talked about freeing the serfs, building schools for all young Russians, and even giving up the throne and making Russia a republic. He introduced several reforms, such as freeing many political prisoners and spreading Western ways and ideas. But he did nothing to lessen the czar's total power or to end serfdom. Alexander knew that Russia's military strength and its position as a major world power depended on income provided by serfdom. Under Alexander's rule, Russia continued to win territory from Persia, Sweden, and the Ottoman Empire.

In June 1812, Napoleon led the Grand Army of France into Russia. He wanted to stop Russian trade with Great Britain, France's chief enemy, and to halt Russian expansion in the Balkan region. The French swept forward and reached Moscow in September 1812. Most of the people had left the city, and Napoleon and his army entered easily.

Soon afterward, fire destroyed most of Moscow. Historians believe the Russians themselves set the fire. After 35 days, the French left the city because they feared they might not survive the approaching bitter Russian winter. They began a disastrous retreat with little food and under continual attack by the Russians. Of the estimated 600,000 French troops in Russia, about 500,000 died, deserted, or were captured. Russia then became a major force in the campaign by several European countries that defeated Napoleon. See **Napoleon I** (Disaster in Russia).

Although Alexander had begun some reforms, harsh rule continued in Russia. Beginning in 1816, many young aristocrats became revolutionaries. They formed secret groups, wrote constitutions for Russia, and prepared to revolt. Alexander died in 1825, and Nicholas I became czar. In December of 1825, a group of revolutionaries, later called the *Decembrists,* took action. At the urging of the Decembrists, about 3,000 soldiers and officers gathered in Senate Square in St. Petersburg, and government troops arrived to face them. After several hours, the Decembrists fired a few shots. Government cannons ended the revolt.

Nicholas I. The Decembrist revolt deeply impressed and frightened Nicholas. He removed aristocrats, whom he now distrusted, from government office and replaced them with professional military officers. He tightened his control over the press and education, reduced travel outside Russia, and prohibited organizations that might have political influence. He established six special government departments. These departments, which included a secret police system, handled important economic and political matters. Through the special departments, Nicholas avoided the regular processes of Russian government and increased his control over Russian life.

In spite of Nicholas' harsh rule, the period was one of outstanding achievement in Russian literature. Nikolai Gogol, Mikhail Lermontov, Alexander Pushkin, and others wrote their finest works. Fyodor Dostoevsky, Leo Tolstoy, and Ivan Turgenev began their careers. Many educated Russians began to debate the values of Westernized Russian life against those of old Russian life. The pro-Western group argued that Russia must learn from and catch up with the West economically and politically. The other group argued for the old Russian ways, including the czarist system, a strong church, and the quiet life of the Russian countryside.

Nicholas became known as the "policeman of Europe" because he sent troops to put down revolutions in Poland and Hungary. Nicholas also declared himself the defender of the Eastern Orthodox Churches and fought two wars with the Muslim Ottoman Empire. In the war of 1828 and 1829, Russia gained much territory around the Black Sea. Russia also won the right to move merchant ships through the straits connecting the Black Sea with the Mediterranean Sea. The Ottoman Empire controlled these straits.

In 1853, the Crimean War broke out between Russia and the Ottoman Empire. Great Britain and France aided the Ottomans. These countries objected to Russian expansion in the Black Sea region. Russia was defeated and signed the Treaty of Paris in 1856. This treaty forced Russia to give up some of the territory it had taken earlier from the Ottoman Empire, and the pact forbade warships on and fortifications around the Black Sea. See **Crimean War; Russo-Turkish wars**.

Expansion in Asia. After its defeat in the Crimean War, Russia began to expand in Asia. In the Far East, Russia won disputed territories from China. In 1858 and 1860, the Chinese signed treaties giving Russia lands north of the Amur River and east of the Ussuri River. By 1864, Russian forces defeated rebel tribes in the Caucasus. Central Asia was won during a series of military campaigns from 1865 to 1876. In 1867, Russia sold its Alaskan territory to the United States for $7,200,000 (see **Alaska** [History]).

Catherine the Great became empress of Russia in 1762. She expanded the country's territory and encouraged the development of the arts. But she preserved and extended serfdom.

Alexander II. Nicholas I died in 1855, during the Crimean War. His son, Alexander II, became czar. Russia's defeat in the Crimean War taught Alexander a lesson. He realized that Russia had to catch up with the West to remain a major power. Alexander began a series of reforms to strengthen the economy and Russian life in general. In 1861, he freed the serfs and distributed land among them. He began developing railways and organizing a banking system. Alexander promoted reforms in education, reduced controls on the press, and introduced a jury system and other reforms in the courts. He also established forms of self-government in the towns and villages.

But many young Russians believed that Alexander's reforms did not go far enough. Some revolutionary groups wanted to establish socialism in Russia. Others wanted a constitution and a republic. These groups formed a number of public and secret organizations. After a revolutionary tried to kill Alexander in 1866, the czar began to weaken many of his reforms. The revolutionaries then argued that Alexander had never been a sincere reformer at all. During the mid-1870's, a group of revolutionaries tried to get the peasants to revolt. They wanted to achieve either socialism or *anarchism* (absence of government) for Russia (see **Anarchism**). After this effort failed, a terrorist group called the People's Will tried several times to kill the czar. Alexander then decided to set up a new reform programme. But in 1881, he was killed by a terrorist's bomb in St. Petersburg.

Alexander III, Alexander's son, became czar and soon began a programme of harsh rule. Alexander III limited the freedom of the press and of the universities,

V. I. Lenin, *with raised arm,* led the Bolshevik take-over of the Russian government in the October Revolution of 1917. He became the first leader of the Soviet Union.

and he sharply reduced the powers of Russia's local self-governments. He set up a special bank to help the aristocrats increase their property. He also appointed officials called *land captains* from among the aristocrats and gave them much political power over the peasants. Alexander started some programmes to help the peasants and industrial workers. But their living and working conditions improved very little during his reign. See **Alexander III** (czar).

Nicholas II became Russia's next, and last, czar in 1894. The revolutionary movement had been kept in check until the 1890's, when a series of bad harvests caused starvation among the peasants. In addition, as industrialization increased, discontent grew among the rising middle class and workers in the cities. Discontented Russians formed various political organizations, of which three became important. (1) The *liberal constitutionalists* wanted to replace czarist rule with a Western type of parliamentary government. (2) The *social revolutionaries* tried to promote a revolution among peasants and workers in the cities. (3) The *Marxists* wanted to promote revolution among the city workers. The Marxists followed the socialist teachings of Karl Marx, a German social philosopher (see **Marx, Karl**). In 1898, the Marxists established the Russian Social Democratic Labour Party.

Between 1899 and 1904, the discontent of the Russian people increased. Worker strikes and other forms of protest took place. In 1903, the Russian Social Democratic Labour Party split into two groups—the *Bolsheviks* (members of the majority) and the *Mensheviks* (members of the minority). V. I. Lenin was the leader of the Bolsheviks, later called Communists. See **Bolsheviks; Mensheviks; Lenin, V. I.**

The Revolution of 1905. On Jan. 22, 1905, thousands of unarmed workers marched to the czar's Winter Palace in St. Petersburg. The workers were on strike, and they planned to ask Nicholas II for reforms. Government troops fired on the crowd and killed or wounded hundreds of marchers. After this *Bloody Sunday* slaughter, the revolutionary movement, led mainly by the liberal constitutionalists, gained much strength. In February, Nicholas agreed to establish an elected Duma (parliament) to advise him. However, more strikes broke out during the summer, and peasant and military groups revolted. In part, the growing unrest was linked to the increasingly unpopular Russo-Japanese War. This war had broken out in February 1904 after a Japanese attack on Russian ships. The war ended with Russia's defeat in September 1905.

In October 1905, a general strike paralysed the country. Revolutionaries in St. Petersburg formed a *soviet* (council) called the Soviet of Workers' Deputies. Nicholas then granted the Duma the power to pass or reject all proposed laws. Many Russians were satisfied, but many others were not. The revolution continued, especially in Moscow, where the army crushed a serious uprising in December.

Each of the first two Dumas, which met in 1906 and 1907, was dissolved after a few months. The Dumas could not work with Nicholas and his high-ranking officials, who refused to give up much power. Nicholas illegally changed the election law and made the selection of Duma candidates less democratic. The peasants and workers were allowed far fewer representatives in the Duma than the upper classes. The third Duma served from 1907 to 1912, and the fourth Duma met from 1912 to 1917. During this period, Russia made important advances in fields such as the arts, education, farming, and industry.

World War I. By the time World War I began in 1914, Europe was divided into two tense armed camps. On one side was the Triple Entente (Triple Agreement), consisting of Russia, France, and Great Britain. Russia and France had agreed in 1894 to defend each other against attack. France and Britain had signed the Entente Cordiale (Friendly Understanding) in 1904, and Russia had signed a similar agreement with Britain in 1907. The Triple Entente developed from these treaties. Opposing the Triple Entente was the Triple Alliance, formed in 1882 by Austria-Hungary, Germany, and Italy. See **Triple Entente; Triple Alliance.**

On Aug. 1, 1914, Germany declared war on Russia. Soon afterward, Russia changed the German-sounding name of St. Petersburg to Petrograd. German troops crushed the Russian army at Tannenberg, in East Prussia. However, the Russians defeated an Austrian army in the Battles of Lemberg in the Galicia region of Austria-Hungary.

In 1915, Austrian and German forces drove back the Russians. The next year, the Russians attacked along a 113-kilometre front in Galicia. They advanced about 80 kilometres. Russian troops moved into the Carpathian Mountains in 1917, but the Germans pushed them back. For the story of Russia in the war, see **World War I.**

The February Revolution. During World War I, the Russian economy could not meet the needs of the soldiers and also those of the people at home. The railways carried military supplies and could not serve the cities. The people suffered severe shortages of food, fuel, and housing. Russian troops at the front were loyal, but the untrained soldiers behind the fighting lines began to question the war. They knew they would probably be sent to the front and be killed. The soldiers and civilians behind the lines grew increasingly dissatisfied.

By the end of 1916, almost all educated Russians opposed the czar. Nicholas had removed many capable executives from high government offices and replaced them with weak, unpopular officials. He was accused of crippling the war effort by such acts. Many Russians blamed his action on the influence of Grigori Rasputin, adviser to the czar and the czarina. The royal couple believed that Rasputin was a holy man who was saving their sick son's life. In December 1916, a group of nobles murdered Rasputin. But the officials who supposedly had been appointed through his influence remained. See **Rasputin, Grigori E.**

In March 1917, the people of Russia revolted. (The month was February in the old Russian calendar, which was replaced in 1918.) Violent riots and strikes over shortages of bread and coal accompanied the uprising in Petrograd, the capital of Russia. (Petrograd was known as St. Petersburg until 1914, was renamed Leningrad in 1924, and again became St. Petersburg in 1991.) Nicholas ordered the Duma to dissolve itself, but it ignored his command and set up a *provisional* (temporary) government. Nicholas had lost all political support, and he gave up the throne on March 15. Nicholas and his family were then imprisoned. Bolshevik revolutionaries almost certainly shot them to death in July 1918. See **Nicholas II** (czar).

Many soviets were established in Russia at the same time as the provisional government was formed. The soviets rivalled the provisional government. Workers and soldiers tried to seize power in Petrograd in July, but the attempt failed.

The October Revolution. In August 1917, General Lavr Kornilov tried to curb the growing power of the soviets. But the attempt failed, and the Russian masses became increasingly radical. On November 7 (October 25 in the old Russian calendar), workers, soldiers, and sailors led by the Bolsheviks took over the Winter Palace, a former royal residence that had become the headquarters of the provisional government. They overthrew the provisional government and formed a new government headed by Lenin. Lenin immediately withdrew Russia from World War I. The new government soon took over Russia's industries and also seized most of the peasants' farm products.

In 1918, the Bolsheviks made Moscow the capital of Russia. They also changed the name of the Russian Social Democratic Labour Party to the Russian Communist Party. This name was later changed to the Communist Party of the Soviet Union. See **Communism.**

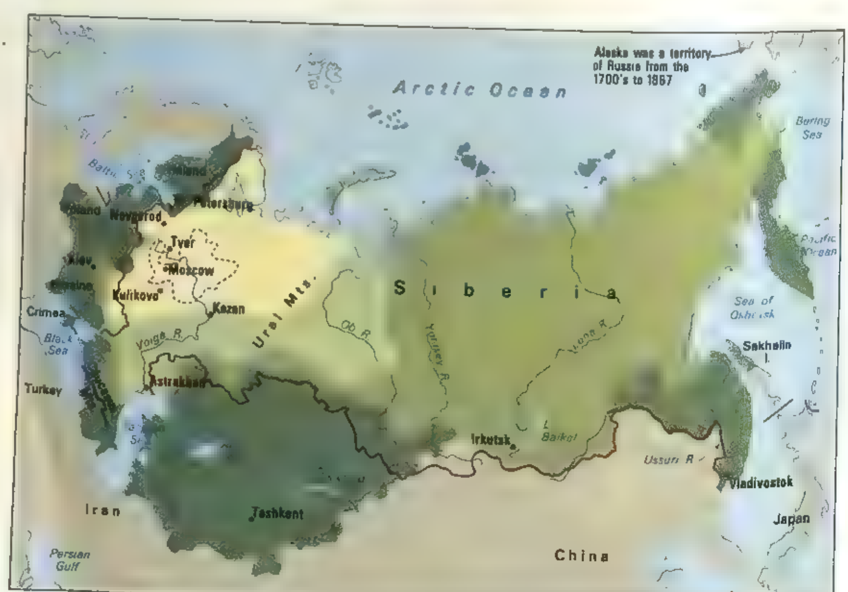
Civil war and the formation of the U.S.S.R. From 1918 to 1920, civil war raged between the Communists and the anti-Communists over control of Russia. The anti-Communists received support from several other countries, including France, Great Britain, Japan, and the United States. Nevertheless, the Communists defeated their opponents. They also established Communist rule in Georgia, Ukraine, eastern Armenia, Belarus, and Central Asia. The civil war contributed to the increasing discontent among the Russian people.

In 1921, more peasant uprisings and workers' strikes broke out. That same year, Lenin established a New Economic Policy (NEP) to strengthen Russia. Under this policy, the government controlled the most important aspects of the economy, including banking, foreign trade, heavy industry, and transportation. But small businesses could control their own operations, and peasants could keep their farm products.

In December 1922, the Communist government created a new nation called the Union of Soviet Socialist Republics (U.S.S.R.). It consisted of four republics—the Russian Soviet Federative Socialist Republic, Byelorussia (as Belarus was renamed), Transcaucasia, and Ukraine. By late 1940, Transcaucasia had been divided into Azerbaijan, Armenia, and Georgia, and 10 more republics had been established, for a total of 16 republics. The new republics included what are now Estonia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova (then Moldavia), Tajikistan, Turkmenistan, and Uzbekistan.

Expansion of Russia

This map shows the increase in territory that took place in Russia between 1462 and 1914. Russia gained these lands through wars, conquests, and annexations. The boundary of present-day Russia appears as a solid red line on the map.



The Karelo-Finnish Soviet Socialist Republic, established in 1940, was changed to an autonomous republic in 1956.

Stalin. Lenin died in 1924. Joseph Stalin, who had been general secretary of the Communist Party since 1922, rapidly gained power. He defeated his rivals one by one. By 1929, Stalin had become dictator of the Soviet Union.

In the late 1920's, Stalin began a socialist economic programme. It emphasized the development of heavy industry and the combining of privately owned farms into large, government-run farms. Many citizens of the Soviet Union opposed Stalin's policies. In the mid-1930's, Stalin started a programme of terror called the Great Purge. His secret police arrested millions of people. Most of the prisoners were shot or sent to prison labour camps. Many of those arrested had helped Stalin rise to power. Stalin thus eliminated all possible threats to his power and tightened his hold over the Soviet Union. See **Stalin, Joseph.**

World War II. By the late 1930's, German dictator Adolf Hitler was ready to conquer Europe. In August 1939, the U.S.S.R. and Germany signed a *nonaggression pact,* a treaty agreeing that neither nation would attack the other. In September, German forces invaded Poland from the west. The Soviet Union's forces quickly occupied the eastern part of Poland.

In June 1941, Germany invaded the Soviet Union and began to advance into the country. The turning point of the war in the Soviet Union was the Soviet defeat of the Germans in the Battle of Stalingrad (now Volgograd) in 1943. Soviet troops then drove the Germans back out of the country and across eastern Europe. They attacked Berlin in April 1945. Berlin fell to the Soviets on May 2, and German troops surrendered to the Allies five days later. In August 1945, the U.S.S.R. declared war on Japan. Japan surrendered to the Allies on Sept. 2, 1945, ending World War II. See **World War II.**

The Cold War. After World War II ended, the Soviet Union extended the influence of Communism into Eastern Europe. By early 1948, several countries had become *Soviet satellites* (countries controlled by the Soviet Union). The Soviet satellites were Bulgaria, Czechoslovakia, Hungary, Poland, Romania, and—later—East Germany.

Joseph Stalin, *fourth from right,* one of the cruellest rulers in world history, was dictator of the U.S.S.R. from 1929 to 1953.

Leonid Brezhnev pursued a policy of friendly relations with the West called *détente.* In the 1970's, Brezhnev, *left,* and U.S. President Richard Nixon signed an agreement limiting production of nuclear weapons as a result of a series of meetings called the Strategic Arms Limitation Talks (SALT).

The U.S.S.R. also influenced Communist regimes in Albania and Yugoslavia. It cut off nearly all contact between its satellites and the West. Mutual distrust and suspicion between East and West developed into a rivalry that became known as the Cold War. The Cold War shaped the foreign policy of the Soviet Union and of many Western countries until the late 1980's. See **Cold War.**

Stalin died on March 5, 1953. In September of that year, Nikita Khrushchev became the head of the Communist Party. In 1958, he also became premier of the Soviet Union. Khrushchev eased the terrorism that had characterized Stalin's dictatorship and relaxed some of the restrictions on communication, trade, and travel between East and West. However, the U.S.S.R. continued working to expand its influence in non-Communist countries. Khrushchev improved Soviet relations with the West, but many of his other policies failed. See **Khrushchev, Nikita S.**

In 1964, the highest-ranking Communists overthrew Khrushchev. Leonid Brezhnev became Communist Party head, and Aleksei Kosygin became premier. Brezhnev and Kosygin increased the production of consumer goods and the construction of housing, and they expanded Soviet influence in Africa.

By the mid-1970's, Brezhnev was the most powerful Soviet leader. He sought to ease tensions between East and West, a policy that became known as *détente.* However, détente began to collapse in the late 1970's. Relations between the Soviet Union and the United States worsened over such issues as Soviet violations of human rights, the Soviet invasion of Afghanistan, and an increase in the number of nuclear weapons by both nations. See **Brezhnev, Leonid I.**

The rise of Gorbachev. In 1985, Mikhail Gorbachev became head of the Communist Party. Gorbachev instituted many changes in the U.S.S.R., including increased freedom of expression in politics, literature, and the arts. He worked to improve relations between the

Mikhail Gorbachev headed the Soviet Union from 1985 until it ceased to exist in 1991. This photograph shows Gorbachev, *right,* greeting a crowd in Moscow.

Soviet Union and the West and to reduce government control over the Soviet economy. In 1989, the U.S.S.R. held its first contested elections for the newly created Congress of People's Deputies. The following year, the government voted to allow non-Communist political parties in the Soviet Union. Many Communist Party members and other Soviet officials opposed Gorbachev's reforms. But in March 1990, Gorbachev was elected by the Congress of People's Deputies to the newly created office of president. See **Gorbachev, Mikhail Sergeyevich.**

The breakup of the U.S.S.R. During the late 1980's, people in many parts of the Soviet Union increased their demands for greater freedom from the central government. In June 1990, the Russian republic declared that laws passed by its legislature took precedence over laws passed by the central government. By the end of the year, all 15 Soviet republics had made similar declarations.

In July 1991, Gorbachev and the leaders of 10 republics agreed to sign a treaty giving the republics a large amount of self-government. Five of the republics were scheduled to sign the treaty on August 20. But on August 19, conservative Communist Party leaders staged a coup against Gorbachev's government. They imprisoned Gorbachev and his family in their holiday home. The president of the Russian republic, Boris Yeltsin, led popular opposition to the coup, which collapsed on August 21. After the coup, Gorbachev regained his office of president. But he resigned as Communist Party leader.

The collapse of the coup renewed the republics' demands for more control over their own affairs. In September 1991, the Congress of People's Deputies established an interim government to rule until a new union treaty and constitution could be written and approved. This government included a State Council, made up of Gorbachev and the leaders of the republics.

On December 8, 1991, Yeltsin and the presidents of Belarus and Ukraine announced the formation of the Commonwealth of Independent States (C.I.S.). They declared that the Soviet Union had ceased to exist and invited the remaining republics to join the commonwealth. The members would be independent countries tied by economic and defence links. Most of the republics joined the C.I.S. Yeltsin took control of what remained of the central government of the Soviet Union, including the Kremlin. On December 25, 1991, Gorbachev resigned as Soviet president, and the Soviet Union ceased to exist.

The new nation. With the end of the Soviet Union, the Russian republic resumed its course as an independent nation. The breakup of the Soviet Union helped eliminate much of the friction that still remained between the East and the West. The Russian government slashed military spending in 1992. The government also made significant cutbacks in the armed forces. The cutbacks, in turn, forced large numbers of former military personnel to find homes and jobs as civilians.

After the breakup of the Soviet Union, Russia agreed to maintain a supply of nuclear weapons. In 1992, the other former Soviet republics with nuclear weapons on their lands—Ukraine, Belarus, and Kazakhstan—agreed to eliminate all nuclear weapons on their territories within seven years.

Russia had to establish new relationships with the members of the C.I.S. Some Russian leaders wanted the country to take a leading role. However, the smaller states feared domination by Russia because of its great size and power.

In March 1992, all but two regions of Russia signed a treaty that formed the basis of the new Russian nation.

Boris Yeltsin, the president of the former Russian republic, continued to serve as president of Russia following the collapse of the Soviet Union at the end of 1991.

Those two regions—Tatar and Chechen-Ingush—wanted greater independence. In May 1992, the Supreme Soviet voted to declare the Soviet government's 1954 grant of Crimea to Ukraine an illegal act. Russia and Ukraine have conducted negotiations on the issue.

Russia also faced the challenges of setting up new economic and governmental systems. The government ended price controls. This action caused prices to soar and resulted in a lower standard of living for the Russian people. The government issued certificates that citizens used to buy shares in state-owned firms. President Yeltsin and his government also took other steps to increase private ownership of businesses.

Opposition to Yeltsin's economic policies grew in parliament, which included many former Communist Party members and Soviet Union leaders. In a referendum held in April 1993, a majority of the voters supported Yeltsin and his economic policies. Opposition to Yeltsin in parliament continued, however. In September, Yeltsin suspended Vice President Alexander Rutskoi, who had become a leader of the anti-Yeltsin group. Later that month, Yeltsin dissolved the parliament. Parliament, in turn, voted to remove Yeltsin from office and to make Rutskoi acting president.

Rutskoi and many other foes of Yeltsin, including Ruslan Khasbulatov and other members of parliament, barricaded themselves in the parliament building in Moscow. At Yeltsin's order, police and interior ministry forces blockaded the building, which is known as the White House. In October, anti-Yeltsin crowds rioted in Moscow and tried unsuccessfully to break up the blockade of the White House. The next day, Yeltsin ordered the military to take control of the White House. Rutskoi and other leaders of the movement against Yeltsin were arrested. Yeltsin then suspended the Constitutional Court—Russia's highest court—claiming it had backed the parliament in the dispute.

In December 1993, the Russian people elected a new parliament. In February 1994, parliament granted an amnesty to Rutskoi and other opponents of Yeltsin.

Study aids

Related articles in *World Book.* For detailed information about Russia between 1917 and 1991, see **Union of Soviet Socialist Republics** and its list of *Related articles.* See also:

Biographies

See the *Related articles* of **Classical music; Drama;** and **Russian literature.** See also:

Alexander I (czar)
Alexander II (czar)
Alexander III (czar)
Catherine
Fabergé, Peter Carl
Ivan
Lenin, V. I.
Nicholas I (czar)
Nicholas II (czar)
Peter I, the Great
Plekhanov, Georgi V.
Rasputin, Grigori Y.
Romanov
Rutskoi, Alexander
Stalin, Joseph
Trotsky, Leon
Vladimir I
Yeltsin, Boris N.

Cities

Arkhangelsk
Astrakhan
Irkutsk
Kaliningrad
Kazan
Magnitogorsk
Moscow
Murmansk
Nizhniy Novgorod
Novgorod
Novosibirsk
Omsk
Rostov-on-Don
Saint Petersburg
Samara
Vladivostok
Volgograd

History

Berlin, Congress of
Crimean War
Czar
Duma
Mongol Empire
Poland (History)
Russo-Japanese War
Russo-Turkish wars
World War I
World War II

Physical features

Amur River
Azov, Sea of
Black Sea
Caspian Sea
Caucasus Mountains
Don River
Dvina River
Franz Josef Land
Kamchatka Peninsula
Kara Sea
Kuril Islands
Lake Baikal
Lake Ilmen
Lake Ladoga
Lake Onega
Lake Peipus
Lena River
Mount Elbrus
Novaya Zemlya
Ob River
Okhotsk, Sea of
Sakhalin
Ural Mountains
Ural River
Volga River
White Sea
Yablonovyy Mountains
Yenisey River

Other related articles

Balalaika
Ballet
Clothing (picture: Traditional costumes)
Commonwealth of Independent States
Doll (Traditional dolls; picture)
Flag
Karelia
Rouble
Russian language
Russian literature
Siberia
Tatars
Theatre (Russia)
Tuva

Outline

I. Government
A. National government
B. Local government
C. Politics
D. Courts
E. Armed forces

II. People
A. Population
B. Ancestry
C. Language

III. Way of life
A. City life
B. Rural life
C. Clothing
D. Food and drink
E. Health care
F. Recreation
G. Religion
H. Education
I. Museums and libraries

IV. Arts
A. Architecture
B. Music
C. Ballet
D. Painting and sculpture

V. Land and climate
A. Land regions
B. Rivers and lakes
C. Climate

VI. Economy
A. Natural resources
B. Manufacturing
C. Agriculture
D. Mining
E. Fishing industry
F. Service industries
G. Energy sources
H. Trade
I. Transportation and communication

VII. History

Questions

Why did Russian soldiers and civilians grow increasingly dissatisfied during World War I?
What is the most developed sector of the Russian economy?
Who led the October Revolution?
What is Russia's most popular sport?
What is the most important type of building in Russian Byzantine architecture?
Who lives in Russia's autonomous territories?
In what part of Russia do most of the population live?
Why did Czar Alexander II enact reforms?
What are some major challenges facing Russia today?

Russian language is one of the world's most important languages. About 153 million people speak Russian as their native tongue. Russian is the third most widely spoken European language, after English and Spanish, and is one of the six official languages of the United Nations. More science material is printed in Russian than in any other language except English.

Russian is the official language of Russia. It was the official language of the Soviet Union before that country was dissolved in 1991. It served as the common means of communication among most of the Soviet Union's non-Russian inhabitants who spoke almost 70 languages and numerous dialects.

Russian, or Great Russian, belongs to the eastern branch of the Slavic linguistic family. Ukrainian (or Little Russian) and Belarusian (or White Russian) also belong to this branch. Russian is closely related to other Slavic tongues, such as Polish, Czech, Slovak, Slovenian, Serbo-Croatian, Macedonian, and Bulgarian. Russian has three main dialects: northern, central, and southern. Modern literary Russian is based on the central dialect, the speech of Moscow and the surrounding areas. The present literary Russian dialect became fairly stabilized by the end of the 1700's. It has changed little since that time.

Alphabet. The Russian alphabet has 33 letters. It is properly called the Cyrillic alphabet, and it is based largely on the Greek alphabet. The letters and their approximate sounds in English are as follows:

Russian		Roman equivalent	Approximate sound in English
А	а	a	far
Б	б	b	bog
В	в	v	vault
Г	г	g	go
Д	д	d	dog
Е	е	ye	yet
Ё	ё	yo	yolk
Ж	ж	zh	azure
З	з	z	zone
И	и	i	feet
Й	й	y	bo*y*
К	к	k	calm
Л	л	l	law
М	м	m	moose
Н	н	n	not
О	о	o	awe
П	п	p	pot
Р	р	r	th*r*ice (rolled)
С	с	s	soot
Т	т	t	toe
У	у	u	fool
Ф	ф	f	for
Х	х	kh	lo*ch*
Ц	ц	ts	its
Ч	ч	ch	*ch*eeks
Ш	ш	sh	*sh*ucks
Щ	щ	shsh	fre*sh sh*erry
Ъ	ъ	—	indicates a break for syllable and *ye*-sound before next vowel
Ы	ы	y	rhythm
Ь	ь	—	usually softens preceding consonant, adding a *ye*-sound, as *n* in canyon
Э	э	e	effort
Ю	ю	yu	use
Я	я	ya	yard

The letters ъ, ы, and ь never occur at the beginning of a word or syllable. Most Russian consonants have two distinct pronunciations—an ordinary *hard* sound and a *soft* sound. Soft consonants are pronounced with the tongue raised and touching the hard *palate* (roof of the mouth). This position adds a short *y* sound to the consonant before the following vowel. The soft vowels—е, ё, и, ю, and я (as well as ь)—are pronounced *eh, oh, ee, oo,* and *ah,* and normally indicate that the preceding consonant is soft. Thus, ву is pronounced *voo,* and вю is pronounced *vyoo,* or somewhat like the French *vu.* At the beginning of a word or syllable, the soft vowels е, ё, ю, and я indicate a distinct *y* sound preceding the vowel: *ye, yoh, yu, ya.*

Russian spelling, like English, tries to combine a historical principle with a phonetic one. That is, some words retain their traditional spelling even though they are no longer pronounced as they used to be.

Grammar. Russian belongs to the Indo-European family of languages. Like Latin, Greek, and German, its words can have many different endings. Nouns have six cases and three genders. Adjectives change their forms to agree with the words they represent or modify. Russian also has special forms for predicate adjectives and for the comparative and superlative forms. Russian verbs have only three tense forms—present, past, and future. Completed, continued, and repetitive actions are expressed by *aspect,* an essential feature of all Russian verb forms. The language has a marked stress. The accent of a given word may change, depending on the grammatical form. The word order in a Russian sentence is not rigid, though important new information tends to be placed at the end of the sentence.

Vocabulary. Comparatively few basic words in everyday Russian are easily recognizable as related to English. But many Russian and English words have a common ancestor. A few Russian words have been adopted into English. They include *czar, sputnik,* and *vodka.*

History. All the Slavic languages probably developed from a primitive Common-Slavic tongue. Old Church Slavonic, the language of the Russian Orthodox Church, resembles Common-Slavic more closely than does any other existing language. This tongue played a role in the history of Russian similar to that played by Latin in the history of the Romance languages. A great many modern Russian words, most of them compound forms with prefixes and suffixes, are actually Old Church Slavonic in origin. Russian has many word pairs. The native Russian form is used for a word with a concrete, everyday meaning, and the Old Church Slavonic is used to express a more technical or abstract concept. This characteristic resembles word pairs in English, which often consist of a common word derived from Anglo-Saxon *(house)* and a more formal word derived from Latin through French *(residence).*

The earliest formal literature in Russia was written chiefly in Old Church Slavonic, with some native Russian words and forms. The oldest manuscripts indicate that a distinct Russian language existed as early as the 1000's. Old Russian legal and business documents were written in the native dialect. By the 1700's, works of literature were written in Russian, which gradually came to replace Old Church Slavonic entirely except for religious use.

Russian literature includes many famous works, such as *The Three Sisters,* a drama by Anton Chekhov. A scene from a production of the play by the Moscow Art Theatre is shown above.

Russian literature

Russian literature includes some of the greatest masterpieces ever written. Russian authors have used all literary forms, but are best known for their novels and poetry. Style, content, and keen character analysis contribute to the excellence of Russian writing. The most famous Russian works show a deep concern for moral, religious, and philosophical problems.

History has had an important influence on Russian literature. The widespread acceptance of Christianity in Russia during the late 900's resulted in literature that consisted mostly of religious works. Themes of the *Tatar* (Mongol) invasion and conquest dominated Russian literature from the 1200's to the late 1400's. The Tatar occupation kept Russia isolated from Western Europe for more than 200 years. But by the end of the 1600's, translations and imitations of Western European works were appearing in many Russian writings. By the late 1700's, literature included expressions of social protest against the czars, serfdom, and moral and political corruption. The greatest Russian poetry, prose, and drama was written during the 1800's. The mid-1800's was the age of realism in Russian literature. Beginning in the 1890's, an artistic and cultural revival known as the Silver Age emerged. It developed from a combination of Russian religious philosophy, the ideas of the German philosopher Friedrich Nietzsche, and artistic doctrines and poetry from France. Most of the great Russian poets of the 1900's appeared during this period, which ended shortly after the Revolution of 1917. After 1917, literary activity was controlled by the Communist government. In 1922, the Communist government formed the Soviet Union, which existed until 1991. Government censors required that literature portray Soviet society as being full of optimism and joy of life. Writers who ignored such regulations faced the threat of severe punishment. However, the constant struggle of Soviet writers against censorship has led to periods of creative freedom and experimentation.

Early literature

Religious literature. The first Russian literature appeared at about the time of the nation's conversion to Christianity in A.D. 988. The literature, like the new religion, came from the Byzantine Empire and the Slavic kingdoms of Bulgaria and Serbia. The writings were largely religious in the form of sermons, hymns, and biographies of saints. Many of these works, despite their religious themes, were characterized by imagination and vivid details of Russian life. Some works were original, but many were based on Greek writings.

Early Russian literature was written in a mixture of Russian and *Old Church Slavonic,* a related language. Old Church Slavonic came from the Slavic peoples of central and Balkan Europe. The Russians also were Slavs, and could understand the new language without much difficulty. Old Church Slavonic became the official language of the Russian Orthodox Church. Elements of this language's style were used even in nonreligious literature to give it a more dignified tone.

Most of Russia's first literary works were both written and read by clergymen. Until 1564, when the first books were printed in Russia, the clergymen copied all manuscripts by hand.

Nonreligious literature. The *chronicles,* which were records of outstanding events, were probably the most important early nonreligious Russian writings. The capital of each *principality* (region ruled by a prince) had its own chronicle. During the 1100's, some of these chronicles carried frequent warnings against the danger of a divided Russia. Later chronicles, particularly those of Moscow, claimed that their principalities had the right

to reunite and rule all Russia. Much of a chronicle was dry narrative, but some accounts were vivid descriptions of military or political battles. Others were fantastic stories based on legend rather than fact.

The greatest work of early Russian literature was "The Lay of Igor's Campaign," written by an anonymous author of the late 1100's. This epic prose poem, famous for its vivid imagery and nature symbolism, describes the defeat of a Russian prince by the Polovtsians, an Asian tribe, in 1185. This work pleads for cooperation among the princes to prevent a foreign invasion. It warns that squabbles among Russian princes would lead to national destruction. The poem was a prophecy. The Tartars invaded Russia in 1223 and 1237. By 1240, they controlled most of Russia.

The literature of Tartar captivity reflected less original thought than did the literature of any other period in Russian history. Tartar rule, which lasted until 1480, provided the dominant theme of the small amount of literature that did appear. The "Zadonshchina" ("The Battle Beyond the Don"), an important work of the 1400's, describes the first major Russian victory over the Tartars. It describes this great victory with solemnity rather than jubilation. Christian imagery appears throughout "Zadonshchina." This work imitates the literary language and imagery of "The Lay of Igor's Campaign."

Muscovite literature developed as Moscow rose to power following the final defeat of the Tartars in 1480. All Russian-speaking territories were united into a single state under the grand prince of Moscow. Russia eventually became an empire, and the grand prince became known as czar. Main themes of Muscovite literature included the right of Moscow to rule the Russian land, and the czar's right to absolute authority. One work, the *Domostroy (Household Management)*, advises a man to rule his family with complete authority, while obeying God, the czar, and the state. Other works praise the grandeur of the new Russian empire. The most remarkable stylistic development of the Muscovite period is the elaborate *word-weaving*. It emphasizes style rather than content, including the formation of words and complex devices used in speaking and writing.

Beginnings of modern literature

Western influences. The 1600's saw an almost complete reshaping of Russian literature. Western Europe, from which Russia had been isolated since the 1100's, began to have a strong influence on Russian writing. Western works, such as anecdotes, fables, moral tales, poetry, and stories of knighthood, were translated and imitated. For the first time, rhymed verse appeared in Russian literature. Russian folklore provided a source for many fairy tales, *satires* (writings that ridiculed people or their actions), and other works. Some authors discarded Old Church Slavonic, the old literary language, and wrote in Russian.

The greatest writer of the new literature was Avvakum, a conservative clergyman who belonged to a group called the *Old Believers*. This group opposed changes made in the ritual of the Russian Orthodox Church in the 1650's, which led to a split in the church. Avvakum's autobiography illustrates his colourful per-

Important periods in the development of Russian literature

Early Russian literature (Late 900's to 1600's)	**The age of romanticism** (Late 1700's to the early 1840's)	**The age of realism** (Early 1840's to the early 1900's)
Early Russian literature consisted primarily of religious works written by clergymen. Some important nonreligious writings, mostly historical works, also appeared during this period. The chronicles "The Lay of Igor's Campaign" The "Zadonshchina" **Beginnings of modern Russian literature** (1600 to the late 1700's) Western Europe began to have a strong influence on Russian literature during the 1600's. Russian authors translated English, French, and German writings and imitated Western literary forms. Archpriest Avvakum Antioch Kantemir Mikhail Lomonosov The classical movement, which began in Western Europe, appeared in Russia in the 1740's. Classical writers followed the formal rules of composition developed by the Greeks and Romans. Alexander Sumarokov Gavriil Derzhavin	The romantic movement in literature developed as a revolt against classicism. Romantic writing featured a new freedom of form and admiration for human emotion. **Sentimentalism** (Late 1700's and early 1800's) Nikolai Karamzin *Letters of a Russian Traveller* (1789-1790) **Preromanticism** (Early 1800's) Vasili Zhukovsky Konstantin Batyushkov **Early romanticism** (1820 to the early 1830's) Alexander Pushkin *Eugene Onegin* (1825-1832) *Boris Godunov* (1825) Alexander Griboyedov *Woe from Wit* (1825) **Late romanticism** (Early 1830's to the early 1840's) Mikhail Lermontov *A Hero of Our Times* (1840) Nikolai Gogol *Taras Bulba* (1835) *Dead Souls* (1842)	Realism in literature was a reaction against romantic writing. The realists felt that literature should portray life honestly. Russian realists wrote about social and political problems. **Early realism** (Early 1840's to the early 1860's) Ivan Turgenev *Rudin* (1856) *Fathers and Sons* (1862) Alexander Ostrovsky *Poverty Is No Crime* (1854) *The Storm* (1860) **The period of great Russian novels** (Early 1860's to the early 1880's) Leo Tolstoy *War and Peace* (1869) *Anna Karenina* (1875-1877) Fyodor Dostoevsky *Crime and Punishment* (1866) *The Brothers Karamazov* (1879-1880) **Late realism** (Early 1880's to the early 1900's) Anton Chekhov *Uncle Vanya* (1899) *The Three Sisters* (1901) Maxim Gorki *The Lower Depths* (1902)

sonality and religious convictions. His expressive language and vivid descriptions of daily life make his writings some of the most revealing works of this period.

Simeon Polotsky, a monk who received a Western education in Kiev, was an outstanding author of the period. His most important contribution to literature was the introduction of a rigid syllabic system into Russian verse. Each line of poetry has a fixed number of syllables with regularly placed pauses. Polotsky wrote quaint but serious verse. Many of his works praise the czar. He also wrote several plays on Biblical subjects.

Czar Peter I (the Great), whose rule officially began in 1682, westernized Russia. This adoption of Western culture and institutions led to great changes in Russian literature. Peter encouraged the translation of many European works and sent people abroad to study Western ways of life. He also invited Europeans to Russia. European historians, architects, musicians, dancers, and writers came to Russia during and following Peter's rule.

The complete Westernization of Russian literature took place during the 1700's. Despite the many political changes that occurred in Russia, European culture continued to flourish there. Many French, German, and English works influenced Russian authors.

Antioch Kantemir, a leading poet and diplomat, wrote nine satires in syllabic verse supporting Peter the Great's reforms and the spread of Western culture. Kantemir used everyday speech in his works, which helped his characters appear lively and typically Russian.

Mikhail Lomonosov has been called the founder of modern Russian literature and the forerunner of classicism. His dignified *odes* (lyric poems) praise the czar and the greatness of God. Lomonosov introduced the modern Russian type of verse, featuring a regular pattern of stressed and unstressed syllables. He also established a system of three literary styles. These styles varied among (1) the highest, or most dignified, language; (2) the middle language based on spoken Russian, but without the vulgarisms; and (3) the lowest, or most popular, speech.

The classical movement, introduced by Lomonosov's literary reforms, emerged fully in Russia in the 1740's. The classical movement stressed the importance of reason and analysis in the interpretation of life. Classicism came to Russia as part of the continual cultural flow from Western Europe. It followed strict rules for composition, style, and subject matter. These guidelines were inspired by ancient Greek and Roman literature and were influenced by the literary criticism in *The Art of Poetry* (1674) by Nicolas Boileau-Despréaux of France.

The most typical Russian classicist was Alexander Sumarokov. His works included fables, plays, satires, and songs. Many of his comedies were amusing, but his tragedies were crude and monotonous.

Vasili Ivanovich Maykov, one of Sumarokov's followers, wrote a mock epic poem called *Elisey, or Bacchus Infuriated* (1771). This realistic work describes the hilarious adventures of a drunken coachman. Another important classicist, Denis Fonvizin, became famous for his satirical comedies. *The Adolescent* (1782), though it has obvious flaws, is considered his finest work. This play attacks the ignorance and cruelty of country landowners.

<table>
<tr><th>Literary revival
(1890's to 1920's)</th><th colspan="2">Soviet literature
(1917 to 1991)</th></tr>
<tr><td rowspan="2">The spirit of revolution, which swept through the country from the 1890's until the 1920's, was a period of social change with a renewed interest in the arts. This period was known as the Silver Age.

Symbolism, a literary trend that began in Russia during the mid-1890's, opposed a realistic portrayal of life in writing.

Alexander Blok
The Twelve (1918)
Andrey Bely
St. Petersburg (1913-1914)

Post-symbolism, which began about 1910, was a revolt against the vague works of the symbolists. It stressed simplicity and clarity in literature.

Anna Akhmatova
Osip Mandelshtam
Vladimir Mayakovsky</td><td colspan="2">For many years after the Bolshevik Revolution of 1917, the government attempted to use literature as a propaganda tool. Soviet writers were told to present only favourable descriptions of life in the Soviet Union, and government censorship limited the free expression of ideas. The works of many Soviet writers were published only outside the Soviet Union. During the late 1900's, the government greatly relaxed its censorship policy.</td></tr>
<tr><td>During the 1920's, several important works were written about the revolution and the civil war that followed from 1918 to 1920.

Isaak Babel
Red Cavalry (1926)
Alexei Tolstoy
Road to Calvary (1921-1941)

From 1928 to 1932, Soviet writers helped promote Soviet industry by producing works that dealt with such subjects as agriculture and manufacturing.

Valentin Kataev
Time, Forward! (1932)

Many works written during the 1930's and 1940's were based on historical events, such as the revolution or the war against Germany from 1941 to 1945.

Mikhail Sholokhov
Quiet flows the Don (1928-1940)
Konstantin Simonov
Days and Nights (1943-1944)</td><td>The 1950's and 1960's were marked by the appearance of several liberal writers who attacked social and political conditions in the Soviet Union.

Poets

Yevgeny Yevtushenko
Andrey Voznesensky

Novelists

Boris Pasternak
Doctor Zhivago (1957)
Alexander Solzhenitsyn
The First Circle (1968)
The Gulag Archipelago, 1918-1956 (1973-1976)

In the 1970's and 1980's a number of writers continued to criticize the selfishness and hypocrisy of Soviet society.

Yuri Trifonov
Another Life (1975)
Vladimir Voinovich
The Life and Extraordinary Adventures of Private Ivan Chonkin (1975)</td></tr>
</table>

Fonvizin was forced out of literature in the 1780's after Empress Catherine II (the Great) prohibited him from publishing his writings.

The outstanding poet of the 1700's was Gavriil Derzhavin who, like Lomonosov, wrote mostly odes. In "Ode to Felitsa" (1783) and other poems, Derzhavin praises Catherine and ridicules the vices of her courtiers. He did much to make the ode a fresh poetry of life and feeling. His work marked the turning point in Russian literature from classical to romantic writing.

During the late 1700's and early 1800's, fables were the most popular form of literature. Russia's greatest writer of fables was Ivan Krylov. His works, typically Russian in their everyday language and humorous characterizations, ridiculed ignorance and vanity.

The age of romanticism

Romanticism, which originated in Germany and England, stressed the full expression of emotions in literature. The movement developed as a revolt against the logic and formality used by classical writers. Romantic characteristics began to appear in Russian literature during the late 1700's. But romanticism did not become a significant influence until the early 1800's.

Sentimentalism, one of the strongest early romantic trends, came to Russia from Europe in the 1790's. The followers of this movement emphasized the importance of feelings and imagination. However, the sentimentalists continued to use classical forms in poetry.

The leading Russian sentimentalist was Nikolai Karamzin. His *Letters of a Russian Traveller* (written in 1789 and 1790) is filled with the excitement of his trip to the West and his meetings with famous writers. "Poor Liza" (1792) is a popular tale about a peasant girl who was abandoned by her lover, a nobleman. Karamzin's *History of the Russian State* (1816-1829) is still an important work of Russian history.

Preromanticism. Another group of writers of the early 1800's are known as preromantics. They showed a greater interest in nature and more love of moods than did the sentimentalists. Preromantics continued to use forms of classicism in their works. Leading preromantic writers included Vasili Zhukovsky and Konstantin Batyushkov. Zhukovsky, a gifted poet, translated works of several German and English romantics. Batyushkov was famous primarily for his *elegies* (poems for the dead). He also wrote sad, passionate lyrics.

Early romanticism. A new generation of poets appeared during the 1820's, marking the beginning of the *Golden Age* of Russian poetry. These poets, like the preromantics, combined classical forms with romantic sentiments. However, the early romantics showed a greater concern for individual freedom and an interest in a broader range of subjects. The poets of the Golden Age were strongly influenced by two English authors, William Shakespeare and Lord Byron.

Russia's greatest lyric poet, and the leading writer of early romanticism, was Alexander Pushkin. His poems are distinguished by their economical but very expressive language. Pushkin's concise style makes his works difficult to translate, or to be appreciated in any language except Russian. Pushkin's narrative poems deal with the place of human beings in society. Many of his main characters, such as the title hero of *Eugene Onegin* (1825-1832), are unable to find a purpose in life. They end up bored and insensitive to love.

In 1825, Pushkin wrote *Boris Godunov,* a historical drama in blank verse. It was an attempt to introduce Shakespeare's type of chronicle play into Russian drama. "The Bronze Horseman" (written in 1833), one of Pushkin's greatest narrative poems, centres on Peter the Great's westernization of Russia and its effect on ordinary Russians. The work tells of both the glorious and tragic consequences of his grand design for Russia.

Pushkin also wrote a novel and several stories. His novel, *The Captain's Daughter* (1836), resembled the historical novels of Sir Walter Scott, a Scottish romantic. One of Pushkin's best stories, "The Queen of Spades" (1834), is about a gambler who goes mad after failing to win a fortune at cards.

Another important writer of the 1820's was Alexander Griboyedov. His most famous work, *Woe from Wit* (1825), is a satirical comedy written in rhymed verses. The hero, Chatsky, like Pushkin's Eugene Onegin, is unable to fit into the society of his time. Onegin and Chatsky became known as "superfluous" or useless men whose weak natures prevent them from pursuing constructive goals. Later writers used this character type to describe Russian nobles who could not provide strong liberal leadership in support of political and social reforms. The superfluous man appeared in Russian literature several times during the 1800's and early 1900's.

Late romanticism featured a new freedom of form and style, and an admiration for human feelings and passions. This movement, which began in the 1830's, also stressed the deep significance of dreams, visions, and fantasies. Political and moral corruption were the themes of some late romantic Russian literature. However, censorship had become severe under Czar Nicholas I, whose rule began in 1825. There was strict censorship of all literary works critical of Russian society, especially serfdom. The leading writers of this period included Mikhail Lermontov, Fyodor Tyutchev, and Nikolai Gogol.

Lermontov was an outstanding poet and novelist. His lyrics expressed intense frustration and boredom with life in Russia. In several of his poems, Lermontov dreamed of an unattainable paradise. Pride and unrestrained desire cause the hero of *The Demon* (about 1839) to lose this ideal state. Lermontov's *A Hero of Our Times* (1840) was the first psychological novel in Russian literature. The hero, Pechorin, is another superfluous man. He wastes his life in senseless adventures because the strictness of Russian social and political life keeps him from any useful activities except his military duties.

Tyutchev, another brilliant romantic poet, wrote on such themes as the place of human beings in the universe, the limits of their understanding of nature, and their ability to communicate through language. His poems include "Silentium" (1830), "A Dream at Sea" (1833), and "Nature Is Not What You Think" (1836).

Gogol was one of Russia's greatest writers. His early works give colourful descriptions of life in Ukraine, where he was born. *Taras Bulba* (1835), a historical novel, praises the past glory of Ukrainian Cossacks. Literary critics regarded many of Gogol's later works as political satires. But Gogol's main objective was to make fun of humanity's spiritual weaknesses. The characters in

The Inspector-General (1836) represent common human vices. "The Overcoat" (1842), the story of a pathetic copy clerk, protests the spiritual poverty of human beings. *Dead Souls* (1842), though never completed, is one of Gogol's most brilliant satires. The hero of the story travels around Russia buying up titles to dead serfs whose names are still in the census. He plans to use the titles in a swindle. This tale, an attack on moral corruption, was misinterpreted by readers of Gogol's day as a criticism of political corruption.

The age of realism

In the 1840's, realism emerged as an important literary trend in Russia. Its followers were influenced partly by the teachings of Vissarion Belinsky, a leading literary critic. Belinsky believed realistic literature should give an honest picture of life and, at the same time, preach social reform. His view that literature should serve the needs of society became an established principle in Russian criticism during much of the 1800's. This view continued to influence the choice of themes and their treatment in Russian prose in the 1900's.

Early realism. The literature of the 1840's and the 1850's had both romantic and realistic traits. Early realists combined romantic sentiments and feelings with realistic portrayals of social and political problems.

Ivan Turgenev, an outstanding novelist and playwright, displayed a deep understanding of Russian society and people. *A Sportsman's Sketches* (1852) helped stir up public sympathy for Russia's serfs. Turgenev described the serfs as kind and dignified, and portrayed landowners as crude and insensitive. In *Rudin* (1856), Turgenev shows the traditional superfluous man as a frustrated liberal. *Fathers and Sons* (1862) was superior to Turgenev's other works in dramatic content and in character analysis. It shows the *nihilists* (radical Russian youths of the early 1860's) as strong-willed, and disrespectful of authority and tradition. They want to change Russian society, but the country is not yet ready for a revolution. The hero, Bazarov, dies inactive and frustrated. One of Turgenev's favourite themes was young love, the subject of *Asya* (1858) and *First Love* (1860). In *First Love,* a boy experiences his first crush, only to learn that the girl is his father's mistress. Turgenev's most successful play, *A Month in the Country* (completed in 1850), tells a similar story. A girl and her guardian compete for the love of a young tutor.

The novelist Ivan Goncharov tried to convince Russian liberals that only practical action, not sentiment, leads to social reform. In *Oblomov* (1859), the superfluous man is portrayed as a well-bred landowner, Oblomov, a charming and intelligent man whose almost total failure to act keeps him from achieving his youthful dreams. After this novel, Russians began to refer to inactivity within the privileged class as "Oblomovism."

Alexander Ostrovsky, one of the most popular and most productive Russian dramatists, wrote plays criticizing the middle classes. His use of everyday Russian speech gives his work strong national appeal. Ostrovsky's villains, products of the merchant world, are greedy, dishonest, and dominating. In *Poverty Is No Crime* (1854), a selfish businessman decides that his daughter must marry a wealthy swindler. Ostrovsky's greatest work, *The Storm* (1860), tells the tragic story of a merchant's wife who is driven to suicide by her domineering mother-in-law.

Sergey Aksakov, another leading writer of the 1850's, based his vivid descriptions of nature and people on childhood experiences. Unlike other Russian realists, Aksakov neither attacked nor defended Russian society in his writings. His works include *Family Chronicle* (1856) and *The Childhood of Bagrov the Grandson* (1858).

The 1860's and 1870's brought an end to romanticism in Russian literature. Russian realists began to write about social conditions in their works. A simplified prose replaced the elegant style of romanticism. The novel became the principal literary form. Many novels had vivid characters but little plot structure.

Count Leo Tolstoy, perhaps Russia's greatest writer of realistic fiction, produced his major novels during the 1860's and 1870's. Tolstoy discarded romantic values of heroism and spiritual love. Instead, he showed a deep concern for the natural stages of human development, such as birth, marriage, and death. Tolstoy's magnificent novel *War and Peace* (1869) captures the colour and fire of the French invasion of Russia in 1812. But the novel also opposes war and reveals Tolstoy's desire for a quiet life in close harmony with nature. In *Anna Karenina* (1875-1877), Tolstoy attacked romantic love as self-indulgence, and encouraged a sense of moral duty and love of family instead. "The Death of Ivan Ilyich" (1886) is a terrifying picture of a man's death and his acceptance of his doom as a natural end to life.

Fyodor Dostoevsky was another great Russian novelist. His works are famous for their dramatic portrayals of inner conflicts. His characters experience a violent spiritual struggle between their belief in God and their strong sense of pride and self-centredness. *Crime and Punishment* (1866), Dostoevsky's most exciting novel, describes the drama of a murderer who is tortured by his conscience. The hero is spiritually redeemed when he finally confesses his crime and accepts the punishment. *The Possessed* (1871-1872), also known as *The Devils,* portrays political radicals as ambitious men who turn against God. *The Brothers Karamazov* (1879-1880), Dostoevsky's last and greatest novel, tells about the murder of an evil man by one of his four sons. The symbolic redemption of the other sons represents the author's faith in the saving power of God.

Late realism. Alexander III, who became czar in 1881, opposed many of the reforms made by his father, Alexander II. Themes of despair and bitterness, resulting from the czar's harsh rule, appeared in Russian writings of the 1880's and 1890's. Stories and plays became the major literary forms of late realism.

Anton Chekhov was a leading writer of short stories and plays. Many of his works deal with the boredom and frustration of life. "Ionych" (1898) tells the story of a sensitive, idealistic doctor who becomes lazy and conceited as he grows older. *Uncle Vanya* (1899) is a drama about an intellectual who realizes his life, which he thought he had devoted to idealism, has been wasted. *The Three Sisters* (1901) describes a family whose members are too weak-willed to change their dull lives. The decay of the landowning nobility is the subject of Chekhov's last play, *The Cherry Orchard* (1904).

Maxim Gorki, the last of the great Russian realists, wrote novels, plays, and stories. His early works, reflect-

ing his Communist philosophy, describe the terrible poverty of the lower classes. Gorki's most famous play, *The Lower Depths* (1902), dramatizes the miserable lives of the inhabitants of a dosshouse. A frequent theme of Gorki's later works was the decline of the upper middle class, shown in the novel *The Artamanovs' Business* (1925). Gorki also wrote a multivolume autobiography and published reminiscences of his meetings and friendships with leading Russian authors.

Literary revival

A spirit of revolution spread throughout Russia from the 1890's until the 1920's. This period was known as the Silver Age. This period of social upheaval and transition was also a time of tremendous vitality and renewal in the arts, especially literature.

Symbolism in Russian poetry and fiction began in the mid-1890's. The symbolists opposed the realistic portrayal of everyday life and its problems. Russian writers, particularly Tyutchev, Lermontov, and Dostoevsky and several authors of Western Europe inspired the symbolists. Followers of the movement returned to the dreams and fantasies of the romantics. Some concentrated on religious and philosophical theories. Leading symbolists included Alexander Blok and Andrey Bely.

Blok, a poet, expressed his religious ideals in his early works. His later poetry describes the ugliness of the world. Blok's most famous work, *The Twelve* (1918), interprets the *Bolshevik* (Communist) revolution of 1917 as a spiritual purification of Russia.

Bely was an outstanding novelist and also a poet. His *St. Petersburg* (1913-1914) pictures the Russian capital as a place where Eastern and Western philosophies meet and conflict with almost explosive violence.

Leonid Andreyev combined elements of realism and symbolism in his works. He wrote sensational stories with themes of sex, madness, and terror. Examples of this style include the short story "The Red Laugh" (1904) and the play *He Who Gets Slapped* (1915).

Another leading writer of the early 1900's was Ivan Bunin. Although he was not a symbolist, his work, dominated by themes of love and death, resembles the literature of the symbolists. Bunin's masterpiece, "The Gentleman from San Francisco" (1915), is a story about an American millionaire who works too hard and is later unable to enjoy life.

Post-symbolism grew out of symbolism and represented a revolt against the vague, philosophical works of the symbolists. It began in Russia around 1910. The *acmeists,* one of the most important post-symbolist groups, began to write poetry that focused on the present world. They used clear-cut images and more concrete language. Leading acmeists included Nikolai Gumilev, Osip Mandelshtam, and Anna Akhmatova. A radical post-symbolist group called the *futurists* departed from traditional poetic themes and diction. Vladimir Mayakovsky, the most famous futurist and later an outspoken Communist, shocked readers with his strong language and unusual imagery.

Boris Pasternak, one of the greatest poets of the 1900's, created highly original poetry about nature and life. His collections of poetry include *A Twin in the Clouds* (1914) and *My Sister Life* (1922). He achieved world fame with his epic novel *Doctor Zhivago* (1957). Marina Tsvetaeva, another great poet, experimented with Russian sounds and words. She strongly influenced the younger generation of Russian poets.

Soviet literature

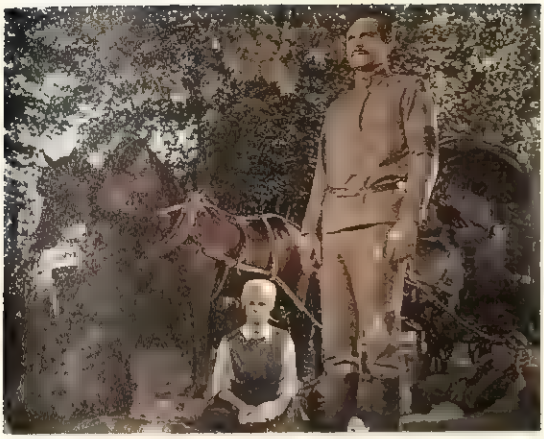
The Communist Revolution of 1917 marked the beginning of a new era in Russian literature. The government greatly tightened censorship, which had existed under the czars. Many writers who opposed the Soviet government left the country or were imprisoned or executed. Those who remained had to serve the interests of the state. Soviet writers were told to describe Soviet life as happy and prosperous.

From 1917 to 1920. Following the revolution, literary activity decreased considerably. Publishing houses closed, and book production and sales dropped. Newspapers and magazines became political tools of the Communist Party. Printing presses were taken over by the state. The government encouraged the development of a *proletarian* literature to express the interests of Russian workers and peasants. However, few works of value were written during this period.

The period of rebirth in Russian literature occurred during the 1920's. The poor writing of the first few years of Communist rule resulted in a more lenient government policy. The government restored a certain amount of literary freedom, and reopened publishing houses. It also permitted literary criticism to resume. A new group of poets and novelists called *fellow travellers* appeared in the Soviet Union. Isaak Babel wrote a series of stories called *Red Cavalry* (1926) about the horrible conditions resulting from war. Leonid Leonov, inspired by Dostoevsky, told about the psychological effects of the revolution on the Russian people. His greatest novels are *The Badgers* (1924) and *The Thief* (1927). Alexei Tolstoy wrote *Road to Calvary,* a three-novel work consisting of *The Sisters* (1921), *1918* (1927), and *Bleak Morning* (1941). The novels deal with Russian intellectuals and members of the Russian middle class from 1914 to 1920.

The period of industrial literature began in 1928 with the Soviet Union's First Five-Year Plan. This plan aimed in part to build up Soviet industry. Writers were expected to produce works concerning economic problems. During this period, *factory* and *production novels* appeared in the Soviet Union. They dealt with such subjects as the building of a factory or the organization of collective farming. Most of this literature is inferior, but a few works, such as *Time, Forward!* (1932) by Valentin Kataev, are interesting and skilfully written.

The period of socialist realism started in the early 1930's. The government, headed by Joseph Stalin, banned all private literary organizations and established the Union of Soviet Writers. The union, which all professional writers were required to join, endorsed the newly developed theory of *socialist realism.* According to this doctrine, the main purpose of literature is to portray the building of a socialist society. The government-controlled union ordered Soviet authors to produce optimistic works that were easy to understand and similar to the style of such writers as Tolstoy and Gorki. Censorship eliminated undesirable material from manuscripts. By forcing writers to meet the requirements of socialist realism, the government gained more control over literature. Writers who ignored the doctrine were expelled



Dr. Zhivago, a novel by Boris Pasternak, describes the suffering and disorder of the Russian Revolution. It was banned in the Soviet Union until 1988, but read in many other countries. In 1965, it was made into a film, *above.*

from the union. This meant the end of their careers. Some writers were imprisoned.

Historical literature became common during the 1930's and early 1940's. One of the finest works about the revolution and the civil war was *Quiet Flows the Don* (1928-1940) by Mikhail Sholokhov. This long epic novel tells the story of a young Cossack whose happiness is destroyed by the tragedy of war. Sholokhov also wrote *Virgin Soil Upturned* (1932, 1955-1960), which describes the problems of peasants living on collective farms. Sholokhov received the Nobel Prize for literature in 1965.

World War II. During the war against Germany from 1941 to 1945, the Soviet government gave writers somewhat greater freedom. Soviet leaders were more interested in fighting the Germans than in building socialism. Themes of individual suffering and death dominated this period. *Days and Nights* (1943-1944) by Konstantin Simonov was one of many patriotic war novels that appeared. The government reestablished strict controls over literature after the war. It also forced several leading authors out of the Union of Soviet Writers. These writers included Anna Akhmatova and Mikhail Zoshchenko, a noted humorist and satirist.

Modern Soviet literature. The death of Stalin in 1953 was followed by another period of relaxed restrictions in Soviet life and literature. This change became known as *The Thaw,* the name of a short novel written by Ilya Ehrenburg in 1954. In contrast to the policy of describing Soviet life as happy and optimistic, Ehrenburg wrote about frustrated, lonely people. Strict censorship returned after the publication in 1962 of *One Day in the Life of Ivan Denisovich* by Alexander Solzhenitsyn. This short novel describes Soviet labour camps during the tyranny of Stalin's time.

A number of young liberal writers appeared in the Soviet Union during the 1960's. Two popular young poets were Yevgeny Yevtushenko and Andrey Voznesensky. Both supported freedom and creativity in Soviet life. In "Babi Yar" (1961), Yevtushenko attacks the prejudice against Jews in the Soviet Union. The main theme of Voznesensky's work is self-analysis through personal experience. Several talented young prose writers, including Vasily Aksyonov, wrote about the shortcomings of Soviet life. Vasily Shukshin and other writers describe the hardships of rural life and the poverty of collective farmers.

Censorship in the Soviet Union prevented many works from being published, though typewritten or mimeographed copies of some of the manuscripts were circulated secretly. Some Soviet writers published works abroad that had not been officially published in their own country. In 1957, Boris Pasternak's novel *Doctor Zhivago* appeared in Italy. The next year it was published in other Western European countries and in the United States. Pasternak was awarded the 1958 Nobel Prize for his works, including this novel. He refused the prize because of pressure from the Soviet government.

Andrey Sinyavsky, writing under the name of Abram Tertz, wrote several short stories that were published abroad beginning in 1959. Sinyavsky's works, including *The Trial Begins,* describe the terrors of life in a police state. Sinyavsky was arrested in 1966 and imprisoned until 1971. In 1973, he was allowed to emigrate to France. *The First Circle* by Alexander Solzhenitsyn was published in the West in 1968. This novel tells about the life of political prisoners in a research institute during the Stalin era. Solzhenitsyn's *The Gulag Archipelago, 1918-1956* was published in the West from 1973 to 1976. It is a history of the Soviet labour camps reserved for political prisoners. Solzhenitsyn won the Nobel Prize for literature in 1970 and was exiled from the Soviet Union in 1974.

From 1970 to 1980, political restrictions increased the difficulty of publishing in the Soviet Union. But a number of writers continued to criticize Soviet society by describing the selfishness and hypocrisy they saw in the country. Valentin Rasputin wrote about the decay of morals and standards in rural areas. Vladimir Voinovich wrote a humorous satire of Soviet life in *The Life and Extraordinary Adventures of Private Ivan Chonkin* (1975). Yuri Trifonov dealt with moral dilemmas faced by Soviet intellectuals in such works as *Another Life* (1975) and *Old Man* (1978).

In the mid-1980's, Soviet leader Mikhail Gorbachev introduced a policy of *glasnost* (openness) that greatly relaxed censorship and led to freer public expression of information and opinion. The Soviet Union began publishing works of important Soviet writers, such as Akhmatova and Pasternak. Pasternak's *Doctor Zhivago* was published in the Soviet Union for the first time in 1988. The era of Soviet literature ended in 1991 when the Soviet Union broke up into a number of independent countries.

Related articles in *World Book* include:

Andreyev, Leonid	Pushkin, Alexander
Bunin, Ivan	Sholokhov, Mikhail
Chekhov, Anton	Solzhenitsyn, Alexander
Dostoevsky, Fyodor	Tolstoy, Alexei
Gogol, Nikolai	Tolstoy, Leo
Gorki, Maxim	Turgenev, Ivan
Pasternak, Boris	Yevtushenko, Yevgeny

Outline

C. The literature of Tartar captivity
D. Muscovite literature

II. Beginnings of modern literature
A. Western influences
B. The classical movement

III. The age of romanticism
A. Sentimentalism
B. Preromanticism
C. Early romanticism
D. Late romanticism

IV. The age of realism
A. Early realism
B. The 1860's and 1870's
C. Late realism

V. Literary revival
A. Symbolism
B. Post-symbolism

VI. Soviet literature
A. From 1917 to 1920
B. The period of rebirth
C. The period of industrial literature
D. The period of socialist realism
E. World War II
F. Modern Soviet literature

Questions

What was the literary language used in early Russia?
What were the *chronicles*?
How did Western culture affect Russian literature?
Who was the founder of modern Russian literature?
What were the characteristics of Russian romanticism?
How did *glasnost* affect Soviet literature?
What was the "superfluous" man?
Who were Russia's greatest novelists?
Who were the *acmeists*? The *futurists*?
What is the theory of *socialist realism*?

Russian Orthodox Church. See Union of Soviet Socialist Republics (Religion); Eastern Orthodox Churches.

Russian Revolution. See Union of Soviet Socialist Republics (History).

Russian wolfhound. See Borzoi; Wolfhound.

Russo-Finnish wars. During World War II, the Soviet Union and Finland fought each other in two wars. They battled in the brief "Winter War" of 1939-1940. The second war, called the "Continuation War," took place from 1941 to 1944. Finland lost both wars.

"The Winter War." Germany conquered Poland in 1939. The Soviet Union feared a German invasion by way of Finnish territory. It maintained that it needed Finland's Karelian Isthmus, only 40 kilometres from the Soviet city of Leningrad, to protect its borders. The Soviet Union demanded that Finland cede this territory and allow it to set up defences along the Finnish coast. The Finns refused.

After fruitless negotiations, the Soviet Union broke diplomatic relations with Finland. On Nov. 30, 1939, the Soviet Union attacked Finland without formally declaring war. At first, the Finns did well. But by February, the tide turned. The Finns suffered heavy losses, and received little help from other countries. On March 12, 1940, Finland had to accept Soviet terms and sign the Peace of Moscow. The Soviet Union took even more than it had first demanded. Finland lost one-tenth of its total area. The Soviet Union also received a 30-year lease on the Hangö Peninsula.

"The Continuation War." Between the first and second Russo-Finnish wars, Finland entered into a closer relationship with Nazi Germany. In September 1940, Finnish military leaders secretly agreed to allow German troops and war supplies to enter Finland. On June 22,

Ski troops, *above,* were among the most effective soldiers in the Finnish Army during the Russo-Finnish Wars.

1941, Germany invaded the Soviet Union. Finland sought to regain territory it lost in the "Winter War." It joined in the war against the Soviet Union. The Soviet Union immediately bombed Finland.

Great Britain had already declared war on Germany. It now declared war on Finland, in December 1941. As the war turned against the Germans, Finnish enthusiasm for the war cooled. In September 1944, Finland accepted severe Soviet peace terms. The treaty restored the 1940 Finnish-Soviet border. The Finns lost the Arctic port of Petsamo and nearby nickel mines. They regained the Hangö Peninsula, but had to grant the Soviet Union a 50-year lease on the Porkkala Peninsula, near Helsinki. Finland agreed to pay the Soviet Union war damages, and to disarm the German troops in Finland. The Soviet Union returned the Porkkala Peninsula to Finland in 1956. In 1962, the Soviet Union leased to Finland part of the Saimaa Canal lost to the Soviet Union in 1940.

See also **Finland** (History).

Russo-Japanese War brought recognition to Japan as a major power of the world. Russia's defeat in the war sharpened the dissatisfaction of its people with the corrupt, poorly run government. This discontent flamed into the Russian Revolution of 1905. The Russo-Japanese War began on Feb. 8, 1904, when Japan attacked Lüshun (also called Port Arthur) in Manchuria. It ended on Sept. 5, 1905, with the signing of the Treaty of Portsmouth.

Underlying causes of the war were the conflicting ambitions of the Russian and Japanese empires. Russia had been expanding its holdings and its interests in the Far East throughout the late 1800's. In 1891, Russia began to build the Trans-Siberian Railway connecting Moscow and Vladivostok. In 1896, Russia signed a treaty with China. The pact allowed Russia to build the Chinese Eastern Railway across Manchuria, and gave Russia partial control of that province. In 1898, Russia leased the

Liaodong Peninsula from China and built there the naval base of Lüshun and the commercial port of Lüda. Russia expanded its influence in Korea during these years. The Boxer Rebellion in China (1900-1901) gave Russia an opportunity to increase its power in Manchuria (see **Boxer Rebellion**).

These Russian moves disturbed the Japanese, who also wanted to extend their power at the expense of China. After Japan defeated China in a war (1894-1895), the Japanese tried to seize the Liaodong Peninsula, but Russia, Germany, and France prevented it. Japan became angry when Russia leased Liaodong.

The two nations were also rivals in Korea, whose location was important to both Japan and Russia. Japan wanted to gain control of Korean trade and industry. It already owned the Korean railways and had sent thousands of Japanese settlers to Korea.

Russian and Japanese diplomats made a series of agreements about Korea and Manchuria. But the Russians broke the agreements. The Japanese therefore made an alliance with Great Britain in 1902 and began to prepare for war. The Russians failed to prepare.

Lüshun attacked. Japan broke off diplomatic relations with Russia on Feb. 6, 1904. On February 8, Vice Admiral Heihachiro Togo's fleet attacked without warning Russian ships at Lüshun. Japan declared war against Russia on February 10. Russia seemed so much more powerful than Japan that most people expected Russia to win the war easily. But Russia had only 80,000 troops in the Far East when the war began. More soldiers and all supplies had to be shipped over 8,000 kilometres

Illustration by E. Hanetzog from *Der Russisch-Japanische Krieg* by Count Ernst von Reventlow.

The Russian fleet was trapped in Lüshun harbour by the Japanese, who attacked without warning on Feb. 8, 1904.

from western Russia on the uncompleted Trans-Siberian Railway. Also, Russia was weakened by social and political problems that led to a revolution in 1905.

Last battles. Japan had 200,000 troops in North China, and another large army nearby. Japan lay closer to the scene of the fighting, and its people supported the government. Japanese warships and mines soon bottled up most of Russia's Pacific squadron in Lüshun. The Japanese destroyed or chased away the few Russian ships that tried to escape from there and from Vladivostok in the Battle of the Sea of Japan. Then the Russians ordered the Baltic Fleet, under Admiral Zinovy Rozhdestvensky, to the Far East. This fleet steamed from the Baltic Sea around Africa, across the Indian Ocean, and into the Korean Strait. But the Japanese fleet nearly annihilated it in the Battle of Tsushima Straits in 1905.

The land war went just as badly for the Russians. This was due to poor leadership, the lack of troops and supplies, and to Japanese skill and hard work. Japanese forces under Marshal Iwao Oyama gradually drove the Russian forces back into Manchuria, and defeated them there at the Battle of Mukden in 1905. After a two-month siege, Lüshun surrendered to Japan. By that time, both countries were ready to stop the war. The Russian government suffered trouble at home, and the Japanese were running out of war funds.

Treaty of Portsmouth. President Theodore Roosevelt of the United States, at the secret suggestion of the Japanese, arranged a peace conference at Portsmouth, New Hampshire, U.S.A., in 1905. The Treaty of Portsmouth gave southern Sakhalin Island to Japan, and forced Russia to remove its troops from Manchuria. Russia also had to give Japan Lüshun and Lüda, and leave Korea for the Japanese. Russia's defeat was one of the main causes of the Russian Revolution of 1905.

Russo-Turkish wars. The Russian Empire and the Ottoman Empire (now Turkey) engaged in almost constant disagreement for about 300 years after the 1600's. They fought frequent wars during this period. At first, the Ottoman Empire was the aggressor. The Turks interfered in the southern borderlands of Russia and supported the Crimean Tartars, the ancient enemies of Russia. Until the late 1600's, Russia avoided open war with the Turks because the Ottoman Empire was much stronger than Russia. But as the empire grew weaker, Russia became stronger and began to expand toward the Black Sea and the Balkans. The Turks controlled both areas. The Ottoman Empire then sought mainly to defend itself, although it occasionally took the offensive, especially when it had the support of another country.

Peter the Great and then Catherine the Great of Russia each fought successful wars against the Turks. Peter forced them out of most of what is now the Ukraine. Catherine's armies conquered the Crimea and completed the opening of the southern lands to Russian settlement. She also forced the Turks to allow Russian merchant vessels to sail the Black Sea, and to grant Russia certain privileges with regard to the Orthodox Christians who lived within the Ottoman Empire. Russia later used this as grounds for claiming to be the official protector of these Christians. This claim resulted in much trouble and proved to be one of the causes of the Crimean War in the mid-1800's (see **Crimean War**).

Russia and Austria allied themselves against the Otto-

man Empire in all three wars fought during the 1700's (1736-1739, 1768-1774, and 1787-1792). Russia and the empire were allies for a brief period in the early 1800's, but this unusual arrangement did not last long. During the 1800's, they fought four wars: 1806-1812, 1828-1829, 1853-1856, and 1877-1878. At the end of the first war, Russia gained Bessarabia and a special position in the Balkans. The second war gave Russia control of the eastern coast of the Black Sea. The Turks won the third war, known as the *Crimean War.* Russia lost its dominant position in the Balkans and Black Sea area. It regained some of these losses in the fourth war, when the two countries signed the Treaty of San Stefano.

A Turkish alliance with Germany in 1914 led directly to another Russo-Turkish war, which was part of World War I. Russia had hoped to gain Constantinople and the Straits of the Dardanelles. Both Russia and Turkey joined the Allies in World War II.

See also **Berlin, Congress of; Crimea.**

Rust is a brownish-red substance that forms on the surface of iron or steel when it is exposed to damp air. The term used alone means *iron rust,* which consists mainly of hydrated iron oxide ($3Fe_2O_3 \cdot H_2O$). Rust is formed by the union of the oxygen of the air with the iron by a process called *oxidation* (see **Oxidation**).

Rust not only corrodes the surface, but also weakens the metal. Long exposure to air and moisture will cause nails to rust off, and rust holes to form in sheet iron. Iron can be *alloyed* (mixed) with other chemical elements to create rust-resistant metals called *stainless steels.* Iron and steel that are not rust resistant should be kept dry or coated with some substance, such as chrome or paint, that will resist the action of oxygen. Polished tools may be easily protected if wiped with a cloth soaked in oil. Coating metal objects with heavy greases or spray-on plastics, or wrapping them in special chemically treated paper, also prevents rust.

A thin coat of rust may be removed from iron or steel by scrubbing in water or by using a polishing powder. A thick coat of rust requires the use of an emery wheel, a grindstone, or a file for its removal. Acids also dissolve rust.

See also **Corrosion; Stainless steel; Tarnish.**

Rust is the name of a group of fungi that are parasites on plants. Rusts are especially harmful to cereal crops. The rust fungi get their name from the spores they produce. These spores are brownish in colour and resemble iron rust. Rusts have special organs resembling threads that grow among the cells of the host plant and absorb the food of the plant cells. This action may cause the leaves and stems to wither. Badly rusted crops produce only shrivelled and worthless grain. Rust also attacks other types of plants. For example, *asparagus rust* damages asparagus, *blister rust* attacks pine trees, and *cedar rust* harms apples.

Every species of rust goes through a certain life cycle. Each period or stage in this life cycle is marked by a different type of spore formation. Some rusts have as many as five different types of spores, while others have only two or three. Some species of rusts spend their entire life cycle on one host. These rusts are called *autoecious.* Other species must spend their life cycle on two different hosts. This type is called *heteroecious.* The second host is known as the *alternate host.*

A common heteroecious type of rust called *black stem rust* attacks wheat plants. This species of rust has five different kinds of spores and must live its life cycle on two hosts, the wheat plant and the American barberry plant (see **Barberry**).

In the spring, small cups filled with spores appear on the lower side of the leaves of the barberry plant. These spores are carried by the wind and spread to wheat plants. The spores germinate and send out threads. These enter the tissues of the wheat plant and there produce reddish spores which are carried to other healthy wheat plants. This is the first stage. The second stage occurs in the autumn, when there is a growth of tiny black spores on the stalks and stubble. These black spores sprout in the spring and produce small colourless spores called *sporidia,* which mark the third stage of life. The sporidia cannot grow on the wheat plant and will grow only on the barberry plant. These sporidia are carried by the wind to the barberry. The fourth stage is the development of tiny yellow spores on the upper surface of the barberry leaves. Later, yellow-orange cups containing spores appear on the undersurface of the barberry leaves. This marks the fifth stage. These spores are not able to infect the barberry plants. They must be carried on the wind to wheat plants. There the life cycle begins again.

One method of controlling a rust which grows on two hosts is to destroy the alternate host. In the case of black stem rust, wheat crops have been saved by destroying barberry plants. Another method is to breed a rust-resistant plant. Rust is sometimes controlled by destroying the crops affected by the disease. Crop rotation also helps to prevent rust.

Scientific classification. Rusts are fungi that belong to the order Uredinales. Black stem rust is *Paccinia graininis;* pine blister rust is *Cronartium ribicola.*

Rutabaga. See Swede.

Ruth, Babe (1895-1948), was the first great home run hitter in American baseball history. His batting ability and colourful personality attracted huge crowds wherever he played. He made baseball more exciting by establishing homers as a common part of the game. Ruth set many major league records, including 2,056 career bases on balls and 72 games in which he hit two or more home runs. He had a .342 lifetime batting average.

George Herman Ruth was born in Baltimore. He began his baseball career in 1914 with the Baltimore Orioles, a minor-league team at the time. Later that same year, he joined the Boston Red Sox as a pitcher. In the 1916 and 1918 World Series, Ruth pitched $29\frac{2}{3}$ consecutive scoreless innings. He won 94 games and lost 46 during his major league career. But Ruth had even greater talent as a hitter and began to play regularly in the outfield in 1918. That year also marked his first big home run season, when he hit 11. In 1920, the Red Sox sold Ruth to the New York Yankees. He attracted so many fans that

Babe Ruth

Yankee Stadium, which opened in 1923, was nicknamed "the House That Ruth Built."

In 1927, Babe Ruth set a record of 60 home runs during a 154-game season. In 1961, Roger Maris hit 61 home runs during a 162-game season. Both feats were considered major-league records until 1991, when Maris' 61 home runs were recognized as the sole record. Ruth hit 714 homers during his career, a record until Henry Aaron hit his 715th home run in 1974.

The Yankees released Ruth after the 1934 season, and he ended his playing career in 1935 with the Boston Braves. In the final game he started in the outfield for Boston, Ruth hit three home runs. In 1936, Ruth became one of the first five players elected to the National Baseball Hall of Fame.

Ruth, Book of, is a book of the Hebrew Bible, or Old Testament. The story centres on the loving and loyal behaviour of Ruth, a Moabite woman married to an Israelite. Left widowed and childless in Moab, Ruth resolves to leave her homeland and follow her mother-in-law, Naomi, to Bethlehem. When Naomi urges her to stay among her people, Ruth responds with the famous words "Whither thou goest, I will go. . . . Thy people shall be my people, and thy God my God. Where thou diest I will die, and there will I be buried" (Ruth 1:16-17). Continuing her bold actions, Ruth manages to obtain food for herself and Naomi and to marry Boaz, a kinsman, and thus secure the family heritage.

The story of Ruth conveys the resources of individuals in dealing with life's problems. It shows Israelite openness to all peoples and offers a glimpse of the independent and courageous actions of women in ancient Israel. Since Ruth is portrayed as the great-grandmother of King David, the book links her to the genealogy of Israel's royal family.

Ruthenia is a historic region in Ukraine. It lies on the southern slopes of the Carpathian Mountains and on the neighbouring southwest highland. Ruthenia covers 12,800 square kilometres and has about 1,196,000 people. Uzhgorod is the region's chief city.

Most Ruthenians are farmers. The principal industries of the region include wood processing, winemaking, and such handicrafts as basket weaving, embroidery, and leathercraft. Ruthenia's chief natural resources are timber and rock salt.

During the 900's and 1000's, Ruthenia was part of Kiev Rus, the first state founded by the Eastern Slavs. It later came under the control of *Magyar* (Hungarian) landlords. In 1919, it became a province of Czechoslovakia.

Ruthenia once had great strategic value because of its location near the borders of several countries. Germany, Hungary, Poland, and the Soviet Union all tried to gain control of the region during the 1930's. In 1938, under an agreement called the First Vienna Award, Hungary took over a strip of Ruthenia along the southern border of the region. The rest of Ruthenia became a self-governing province within Czechoslovakia. Hungary took control of the rest of Ruthenia in 1939, a few months before World War II began. The Soviet Union occupied the region in 1944 and officially annexed it in 1945. The region became part of the Ukrainian Soviet Socialist Republic. In 1991, following an upheaval in the Soviet Union, Ukraine declared itself independent. The Soviet Union ceased to exist later that year.

Ruthenium is a rare, silver-white metallic element. It has the chemical symbol Ru. It is used mainly in jewellery as a hardener of the metals platinum and palladium. Alloys of ruthenium with those metals are highly resistant to wear and are used for electrical contacts in the ignition systems of some aircraft engines.

Karl Klaus, a Russian chemist, discovered ruthenium in 1844. Ruthenium has an atomic number of 44 and an atomic weight of 101.07. It melts at about 2300° C and boils at about 4000° C.

Rutherford, Ernest (1871-1937), a British physicist, established the nuclear model of the atom in 1911. Later, he became the first person to break up the nucleus of an atom. Because of Rutherford's many contributions to science, he is often regarded as the father of nuclear science.

In the nuclear model of the atom, Rutherford theorized that atoms are constructed much like the solar system. That is, a heavy part, called the *nucleus,* forms the centre of each atom. Orbiting around the nucleus, particles of negative electricity, called *electrons,* form the outer part, most of which consists of empty space. In 1913, Niels Bohr combined Rutherford's nuclear model with the quantum theory in the Bohr theory of atomic structure (see **Bohr, Niels**).

In 1902, Rutherford and the British chemist Frederick Soddy published their discovery of *atomic transmutation.* Their observations proved that radioactive elements give off electrically charged particles known as alpha and beta particles. This process changes the *parent* (original) atom into a *daughter* atom. Because of the changes, the new atom is a different chemical element. This achievement won Rutherford the 1908 Nobel Prize for chemistry. Rutherford produced the first artificially created atomic disintegration in 1917 when he bombarded nitrogen atoms with alpha particles and produced *protons,* positively charged particles from the nucleus of the atom.

Rutherford was born in Nelson, New Zealand. He taught at McGill University in Montreal, the University of Manchester, and Cambridge University. In 1903, he was elected a Fellow of the Royal Society. He wrote several books, including *Radioactive Substances and Their Radiations* (1913). In 1931, he received the title of Baron Rutherford of Nelson.

See also **Atom** (The first descriptions of atomic structure).

Rutile (chemical formula, TiO_2) is a titanium-oxide mineral found in the United States, Australia, Brazil, and India. It is an important source of titanium. Most deposits are beach sands. Rutile crystals are usually light brown, but larger crystals are black. Sometimes they have a yellow, blue, or violet tint. The refined white oxide makes the best pigments for white paint. It is also used to colour porcelain. Rutile grains are used to coat welding rods.

See also **Mineral** (picture); **Titanium**.

Rutland (pop. 32,400), once one of England's smallest counties, has been a local government district in Leicestershire since 1974. The main industry of the area is farming. Barley is the most important crop. Beef cattle and sheep graze on fine grasslands in the west. Rutland has some manufacturing, with such products as cement, clothing, engineering goods, and plastics. The district is

administered from Oakham. The other chief town is Uppingham. Both towns have famous independent schools. Rutland Water, a huge lake, is a popular recreational centre with good facilities for fishing and sailing. See also Leicestershire.

Rutskoi, Alexander Vladimirovich (1947-), served as vice president of Russia from 1991 to 1993. He had been elected with President Boris Yeltsin in Russia's first presidential election.

Soon after becoming vice president, Rutskoi began to disagree openly with Yeltsin's policies. He charged that Yeltsin and his advisers had no clear idea of how to improve Russia's economy. He argued that their economic experiments were proving too costly for the Russian people. In 1992, Yeltsin stripped Rutskoi of nearly all official responsibilities. In September 1993, a commission headed by Yeltsin accused Rutskoi of corruption. Yeltsin suspended Rutskoi from office for the period of the investigation of the accusation. Russia's parliament declared the suspension unconstitutional. Later in September, Yeltsin dissolved parliament, which had opposed his economic policies. Parliament, in turn, voted to remove Yeltsin from office and to make Rutskoi acting president. A struggle for power followed. Rutskoi and his allies barricaded themselves in the parliament building in Moscow. In early October, the military, on Yeltsin's orders, forced Rutskoi and his allies out of the building. Rutskoi and other opponents of Yeltsin were arrested and jailed. In February 1994, a new parliament pardoned Rutskoi and he was released from jail.

Alexander Rutskoi

Alexander Vladimirovich Rutskoi was born in Kursk, Russia. He became a military pilot. In the 1980's, he served with Soviet forces that fought in a civil war in Afghanistan. In 1990, he was elected to Russia's parliament.

Ruwenzori Range is a group of mountains that lies just north of the equator in east-central Africa. It extends between Lake Albert and Lake Edward on the border between Uganda and Zaire. The mountain range is about 120 kilometres long and 65 kilometres wide. It has six snow-capped peaks. The highest elevation is Margherita Peak 5,109 metres. The range is not volcanic, but consists of ancient crystalline rock that moved upward from the earth's crust.

Ancient peoples called the range the *Mountains of the Moon.* Ptolemy, the Alexandrian geographer, first used this name on a map. Melting snows from the range feed some of the farthest Nile headwaters.

In 1889, Henry Stanley became the first white man to see the range. He used the local name *Ruwenzori* (rainmaker).

Ruysdael, Jacob van. See Ruisdael, Jacob van.

Ružička, Leopold. See Nobel Prizes (table: Nobel Prizes for chemistry—1939).

Rwanda is a small country in east-central Africa, just south of the equator. It is one of the most crowded African countries. For Rwanda's total population, see the *Facts in brief* table with this article.

Facts in brief about Rwanda

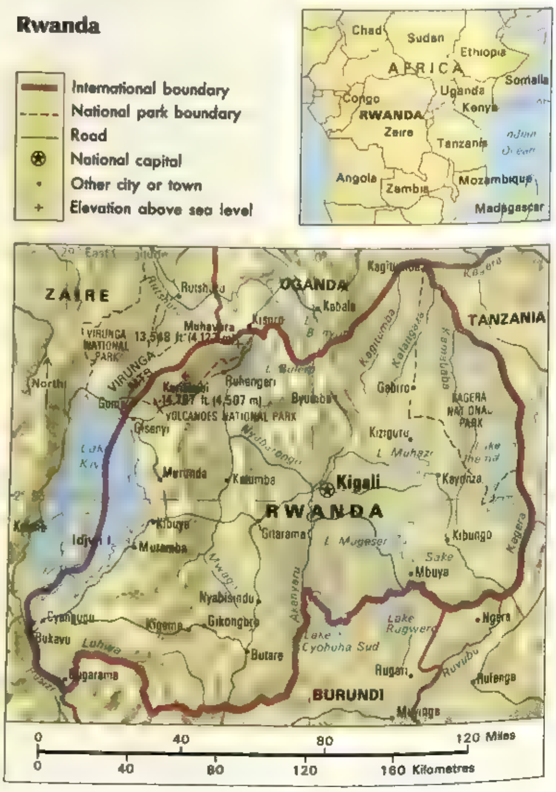
Capital: Kigali.
Official language: French and Kinyarwanda.
Official name: Republic of Rwanda.
Area: 26,338 km². *Greatest distances*—east-west, 233 km; north-south, 177 km.
Population: *Estimated 1996 population*—8,000,000; density, 315 people per km²; distribution, 92 per cent rural, 8 per cent urban. *1991 census*—7,164,994. *Estimated 2001 population*—9,300,000.
Chief products: *Agriculture*—bananas, beans, cassava, cattle, coffee, pyrethrum, sorghum, sweet potatoes, tea. *Mining*—tin, wolframite.
Flag: The flag has three vertical stripes of red, yellow, and green, with a large black *R* in the centre. See Flag (picture: Flags of Africa).
Money: *Currency unit*—franc. One franc=100 centimes.

Although Rwanda is near the equator, it has a cool, pleasant climate. This is because it lies on a series of high plateaus. Rwanda's landscape ranges from volcanic mountains to winding river valleys, and from beautiful lakes to grassy plains. Volcanoes National Park in the Virunga Mountains of northwestern Rwanda is a refuge for mountain gorillas, an endangered species.

Rwanda is one of Africa's poorest countries. It has little industry and more people than the land can support. Kigali, the capital and largest town, has about 157,000 people.

Rwanda once formed the Ruanda, or northern half, of Ruanda-Urundi, a United Nations (UN) trust territory ad-

Rwanda



Rwanda is a country in east-central Africa. Small towns, villages, and farms dot the country's landscape. A street scene in the town of Gitarama is shown on the left.

ministered by Belgium. What is now the nation of Burundi formed the Urundi, or southern half. In 1962, the two parts became the independent nations of Rwanda and Burundi.

A large majority of Rwanda's people belong to the Hutu (sometimes called Bahutu) ethnic group. The Tutsi (sometimes called Watusi) form a minority of the population. Although a minority, the Tutsi dominated the Hutu politically and economically for hundreds of years. In 1959, the Hutu rebelled against the Tutsi. After bloody fighting, the Hutu gained control of the government and the economy. Another major bloody conflict between the two groups took place in 1994, and the Tutsis gained control of the government. See the *History* section of this article for details.

Government. A president heads Rwanda's government. A prime minister heads a cabinet, which helps the president carry out the operations of the government. Under Rwanda's constitution, the people elect the president and the president appoints the prime minister and cabinet members. But in 1994, Tutsi rebels appointed these officials after they overthrew the government.

For a long time, Rwanda had only one party, the National Revolutionary Movement for Development, now called the National Republican Movement for Democracy and Development. In 1991, the Constitution was changed to a multiparty system. Important opposition parties include the Liberal Party, Republican Democratic Movement, Rwandan Socialist Party, and Social Democratic Party.

People. About 90 per cent of the people in Rwanda belong to the Hutu ethnic group. Most Hutu are farmers who raise crops to feed their families. Some also raise cattle or grow coffee, Rwanda's chief export. Other Hutu work in Rwanda's towns. Many Hutu have left Rwanda for jobs in nearby countries. About 5 per cent of the Rwandese people belong to the Tutsi ethnic group. Most Tutsi work in businesses or government agencies.

Pygmies make up less than 1 per cent of Rwanda's population. They once made their living by hunting, but some now live and work in the towns (see **Pygmies**). Only a few Europeans live in Rwanda. Some are farmers who raise tea and pyrethrum, which is used in making insecticides. A few are executives in the mining industry. Others are Christian missionaries.

French and Kinyarwanda are the official languages. Most of the people speak Kinyarwanda, a Bantu language (see **Bantu**). Most of the people are Roman Catholics. A small percentage practises traditional African religions. The Roman Catholic and other Christian churches operate most of the primary and secondary schools. The National University of Rwanda operates in Butare. Public education is free and compulsory for children from 7 to 14 years of age, but there are not enough classrooms to accommodate all the children. About half of all adult Rwandese cannot read and write.

Land. Rwanda covers 26,338 square kilometres. Much of the land is rugged and mountainous. The highest mountains, in the west and northwest, were formed by volcanoes. Lake Kivu and the Rusizi River form Rwanda's western border and are part of Africa's Great Rift Valley. The Kagera River forms the eastern border, and the Akanyaru River forms part of the southern border. The land rises from Lake Kivu to about 2,700 metres above sea level. The Virunga Mountains rise to about 4,510 metres in the northwest. Heavy rainfall in western Rwanda has *leached* (washed away) chemicals that enrich the soil. Heavy farming has also caused erosion.

A series of plateaus in eastern Rwanda range from 1,500 to 2,100 metres above sea level and slope down toward the east. Each plateau is bounded on the east by an *escarpment* (steep edge) with a marsh at its foot. Forests once covered the plateaus, but most of this land has been cleared for farming.

The Great Rift Valley areas in the west have an average annual temperature of 23° C and an average annual rainfall of 75 centimetres. The mountainous areas in the west have an average annual temperature of 17° C and an average annual rainfall of 147 centimetres. The rainfall is greater on the Virunga Mountains. On the pla-

teaus, the temperature averages 20° C annually. Annual rainfall is about 120 centimetres.

Economy. Most Rwandese are farmers. But many farmers can grow only enough food to feed their own families. Food crops include bananas, beans, cassava, sorghum, and sweet potatoes. Some rural people also raise cattle. Coffee is the country's chief export. Tea and pyrethrum (a source of insecticide) are also important exports. The farming varies according to the altitude.

Tin and wolframite are the chief minerals. They account for about one-quarter of the country's exports. Rwanda has few manufacturing industries. It has no railways. The main roads are surfaced, but there are mostly dirt roads. Kigali has an international airport.

The territories of Ruanda (now Rwanda) and Urundi (now Burundi) cooperated closely for many years. Rwanda's exports were shipped through Burundi. But after the fighting between Hutu and Tutsi, relations between the two countries became strained. When possible, Rwandan exports are now hauled to Kampala, Uganda, and then shipped by train to Mombasa, in Kenya. This makes it difficult and expensive for Rwanda to export and import goods and products.

History. What is now Rwanda was first inhabited by Hutu farmers and Pygmy hunters. About 600 years ago, the Tutsi, a warrior people with large herds of big-horned cattle, invaded the area from the north. The Hutu could not defeat the Tutsi, and so each Hutu agreed to serve a Tutsi "lord." The Tutsi agreed to protect the Hutu and allow them the use of some cattle. In this way, the Tutsi dominated the area.

Germany conquered the area that is now Rwanda and Burundi in 1897. It ruled this area as part of German East Africa. Belgian troops occupied the area, then called Ruanda-Urundi in 1916, during World War I. Germany lost its African colonies after the war in 1918, and Ruanda-Urundi became a mandated territory under Belgian administration in 1923 (see **Mandated territory**). In 1946, the area became a United Nations trust territory administered by Belgium.

Political unrest followed the death of *Mwami* (King) Mutara III in 1959. The Hutu rebelled against the Tutsi. Fighting between the two resulted in about 150,000 deaths. The Tutsi suffered the heaviest casualties. During and after the rebellion, about 150,000 Tutsi fled Rwanda to Burundi and other neighbouring countries.

Elections held in 1960 gave the Hutu control of the government. In 1961, the people of Ruanda voted to make their country a republic. Ruanda-Urundi became independent as two countries, Rwanda and Burundi, on July 1, 1962. The people of Rwanda then elected Hutu leader Gregoire Kayibanda as the first president. They reelected him in 1965 and 1969. In 1973, military leaders led by Major General Juvenal Habyarimana, a Hutu, overthrew Kayibanda, dissolved the nation's legislature, and took control of the government. Habyarimana declared himself president. He appointed other military leaders to the government's Cabinet posts. During the 1970's, Habyarimana gradually replaced most of these military leaders with civilians. A new constitution, which established a one-party political system, was adopted in 1978. Habyarimana was elected president in 1978 and reelected in 1983 and again in 1988.

Rwanda made some economic progress under Habyarimana. Production of some goods increased. But poverty remains a severe problem and Rwanda still depends heavily on overseas aid. In October 1990, Rwandese rebels, called the Rwandan Patriotic Front (RPF), had launched attacks against Rwanda's government. Most of the rebels were Tutsis, who had been living in exile in Uganda. Fighting increased in the early 1990's. In 1991, the government changed the constitution to allow for a multiparty political system.

In August 1993, the government and the RPF signed a peace treaty. In April 1994, Habyarimana was killed in a plane crash. Extremist Hutu militias broke the peace. They killed up to 500,000 people, mostly Tutsis. A Hutu-dominated government was formed, but the Tutsi-dominated RPF refused to recognize it. By mid-July, the RPF had defeated the Hutu forces. The RPF took control of the government. But it appointed a multiparty government, including some moderate Hutu officials. About 2 million refugees, mostly Hutus, left Rwanda to escape RPF forces during the fighting. The majority of them went to the area near the town of Goma, Zaire. Tens of thousands of the refugees died from cholera and other diseases.

See also **Burundi; Kigali.**

Ryder, Albert Pinkham (1847-1917), is considered one of the most original of American painters. He is best known for his brooding night scenes of the sea and dreamlike landscapes. His paintings are based on stories from the Bible, Shakespeare, and other literary sources. Ryder conceived simple, bold designs and often used dark and pale tones in dramatic contrast. He laid paint on thickly, working on each painting for a long time, repainting until layers of colour were built up.

Ryder was born in New Bedford, Massachusetts.

Rye is a cereal grain similar to wheat and barley. The plant has slender seed spikes with long, stiff *awns* (beards). The commonest kinds of rye have bluish-green ears when unripe, and yellowish-grey ears when ripe. The grains grow in pairs. Like those of wheat, the grains separate from the chaff when threshed. Rye flowers, unlike those of wheat, oats, and barley, open for pollination. They shed their pollen into the air, and it is spread by the wind. Because rye *cross-pollinates* (pollen is transferred from one plant to another), it is difficult to keep varieties of rye pure. Rye is used to make bread and certain types of liquors. Rye has been raised as a grain since the days of ancient Rome. It probably originated from wild species in eastern Europe or Asia. Wild rye still grows in these regions and in northern Africa.

Production. Rye is an important crop in the cool climates of northern Europe, Asia, and North America. In the Southern Hemisphere, comparatively little rye is cultivated, except in Argentina. Before its breakup, the Soviet Union produced the most rye, about 60 per cent of the world's total crop. Other producers include Poland, Germany, and China. The world produces an average of about 30 million metric tons of rye each year.

Uses. In most countries, rye is used chiefly for human food. The food value of rye is nearly as great as the food value of wheat. But many farmers feed much of the grain to livestock. Rye hay and *middlings* (medium-sized particles that are a by-product of bran flour milling) and rye *bran* (the husks that cover the grain), are often used as livestock feed. Young rye plants make good pasture in

spring and autumn. But sometimes, cows that graze on rye give milk with an unusually strong flavour.

Farmers frequently grow rye to improve or to protect the soil. For example, a crop of rye may be raised alternately with other crops to protect the soil. Then, it is called a *cover crop.* If it is ploughed under before it matures, it is called a *green manure crop.* Rye that is ploughed under returns nitrogen to the soil.

The heavy, black bread of eastern Europe is made from rye. Rye does not contain as much gluten as wheat. Because of this, yeast cannot raise rye dough as easily as wheat dough, and rye bread is heavier, darker and more compact than wheat bread. In some countries, bakers add wheat flour to the rye so that the bread is not so dark. During the past few hundred years, wheat bread has become more popular than rye bread.

Distillers use malt made from rye for rye whiskey and Hollands gin. Rye straw is long, smooth, and easy to bend. Packers use the straw as a packing material. Manufacturers use it to make hats, paper, mats, and mattress stuffing. Rye straw is also used in European countries for thatched roofs because it decays less rapidly than most other kinds of straw.

Construction workers sometimes use rye to conserve soil. They plant rye in the raw soil alongside new roadbeds. The plants grow in the infertile subsoil, and keep it from eroding.

Cultivation. Rye grows well in much poorer soils than those necessary for most cereal grains. Therefore, it is an especially valuable crop in regions where the soil contains sand or peat. Rye plants withstand cold better than other small grains do. Most farmers grow winter ryes, which are planted and begin to grow in autumn. When spring comes, the plants develop and produce their crop.

Like all cereal grains, rye plants are annuals and new seeds must be planted each year. Many farmers use grain drills to plant rye. These machines plant the seeds in rows 15 to 18 centimetres apart. About 93 to 124 kilograms of seed are sown per hectare. In the United States, rye yields an average of about 1,875 kilograms per hectare. In some European countries, the crop may yield two to three times this amount.

A rye seed spike, *left,* has long, stiff beards. Rye grains, *right,* grow in pairs. Rye is a major crop in many countries.

Leading rye-producing countries

Metric tons of rye grown each year	
Soviet Union*	19,554,000 tons
Poland	5,827,000 tons
East Germany†	1,950,000 tons
West Germany†	1,746,000 tons
China	984,000 tons
Canada	682,000 tons
Czechoslovakia*	649,000 tons
Denmark	466,000 tons
Austria	365,000 tons
Spain	316,000 tons

*Figures are for period prior to the country's breakup.
†Germany figures are for period before reunification.
Figures are for a three-year average, 1988-1990.
Sources: Food and Agriculture Organization of the United Nations.

Ergot. A poisonous fungus, called *ergot,* often destroys rye grain. Ergot replaces the grain with a hornlike blackish body several times longer than the normal grain. These ergot bodies poison livestock and human beings who eat the grain or products made from it. This disease is called *ergotism.* But ergot supplies a valuable drug. Doctors use small doses of drugs made from it to ease migraine headaches, to control bleeding, and as an aid to childbirth (see **Ergot**).

Scientific classification. Rye belongs to the grass family, Gramineae. It is *Secale cereale.*

Rye House Plot was a scheme concocted by radical members of the English Whig Party in 1682 and 1683. The conspirators planned to kill Charles II, king of England, and his brother James, Duke of York, who was a Roman Catholic and heir to the throne. Some of the plotters favoured a republic, and others wanted to place Charles's illegitimate son, the Protestant Duke of Monmouth, on the throne. The assassination was to have occurred near a country home called the Rye House as the king and his brother returned to London from Newmarket in Suffolk. The scheme failed after the royal party left Newmarket earlier than expected.

The Rye House Plot is often confused with another plot of 1682 and 1683, which involved a more prominent group of conspirators. In the second plot, Monmouth, Lord Russell, and political theorist Algernon Sidney planned a rebellion to force Charles to support Monmouth as his successor rather than James. Russell, Sidney, and some of their accomplices were tried and executed. Monmouth went into exile.

Ryedale (pop. 90,000), a local government district in North Yorkshire, contains the towns of Malton and Norton, Helmsley, Kirkbymoorside, and Pickering. The main

industries are agriculture and tourism. The district contains part of the North Yorkshire Moors National Park. Helmsley, on the River Rye, has a Norman castle built in the 1200's. Ryedale is administered from Malton. See also **Yorkshire**.

Ryle, Gilbert (1900-1976), a British philosopher, achieved distinction with his book *The Concept of Mind* (1949). In this and other works, he argued that many philosophical dilemmas and absurd theories arise from misinterpretations of linguistic idiom. In particular, he applied this idea to theories about the relationship of mind and body. Ryle was born at Brighton, East Sussex, England. He was Waynflete Professor of Metaphysical Philosophy at Oxford from 1945 to 1968. In 1947, he became editor of the philosophical journal *Mind*.

Ryle, Sir Martin (1918-   ), was the British Astronomer Royal from 1972 to 1982. As a physicist, he became well known for his work on telecommunications and *radio astronomy* (the study of stars using radio waves). He designed equipment to detect extremely weak radio signals from outer space. Ryle was born at Brighton, East Sussex, and educated at Bradfield College and Oxford University. He became a fellow of the Royal Society and was awarded the society's Hughes Medal in 1954. He was made professor of radio astronomy at Cambridge in 1959.

Ryukyu Islands are a group of more than 100 islands in the North Pacific Ocean that belong to Japan. They stretch from the main islands of Japan to Taiwan. They have a land area of 3,120 square kilometres and a population of 1,106,595. Some of the islands have no people. The Ryukyus can be divided into five groups from north to south—(1) the Osumi Islands, (2) the Tokara Islands, (3) the central Ryukyus including the Amami Islands and Okinawa, (4) the Miyako Islands, and (5) the Yaeyama Islands. See **Okinawa**.

People. Farming is the most important occupation of the islanders, though the soil is rocky and hilly. The people grow rice, but their main food crop is sweet potatoes. They export sugar cane and pineapple. Fishing is another important activity for income and food.

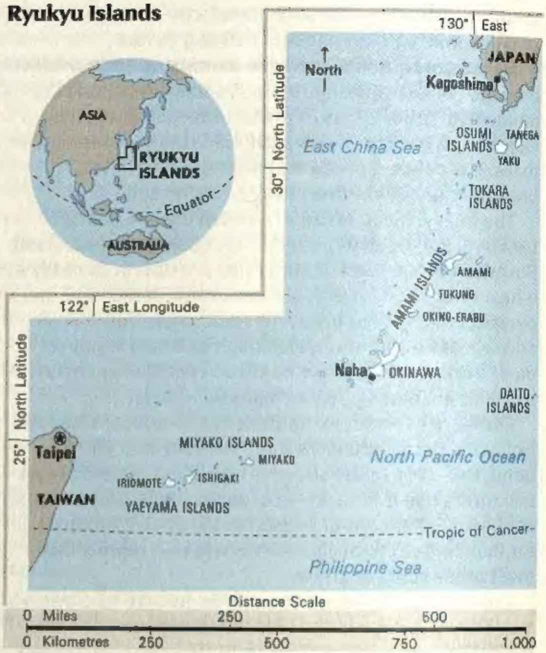
The Ryukyuans speak a language similar to Japanese. Their religion has been influenced by both China and Japan. Burial of the dead in large family tombs and ceremonies honouring ancestors are important parts of the Ryukyuan religion. Ryukyuans also worship things connected with nature, such as trees and fire.

Land and climate. Most of the Ryukyu Islands are mountainous. The highest elevation above sea level, more than 1,800 metres, is on Yaku Island. Some of the islands have active volcanoes.

The Ryukyus have a warm, wet climate. The average temperature is about 21° C, and the annual rainfall ranges from 135 to 305 centimetres. Typhoons bring damaging winds and rains in summer and autumn. Winters are usually cloudy and chilly, with less rain.

History. Ancestors of the Ryukyuans probably came from Japan and Taiwan, and possibly from the Philippines. Some scientists believe that prehistoric people may have lived on the islands in the Ice Age. Chinese and Japanese expeditions stopped in the Ryukyu Islands as early as the A.D. 600's. During the 1400's and 1500's, Okinawa was part of a trade network that linked China, Japan, Korea, and Southeast Asia.

Ryukyu Islands

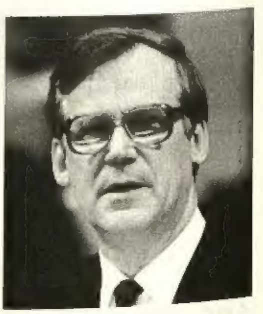


China and Japan both claimed the Ryukyus until 1874, when China signed a treaty recognizing Japanese rule. In 1879, the islands became part of two *prefectures* (provinces) of Japan.

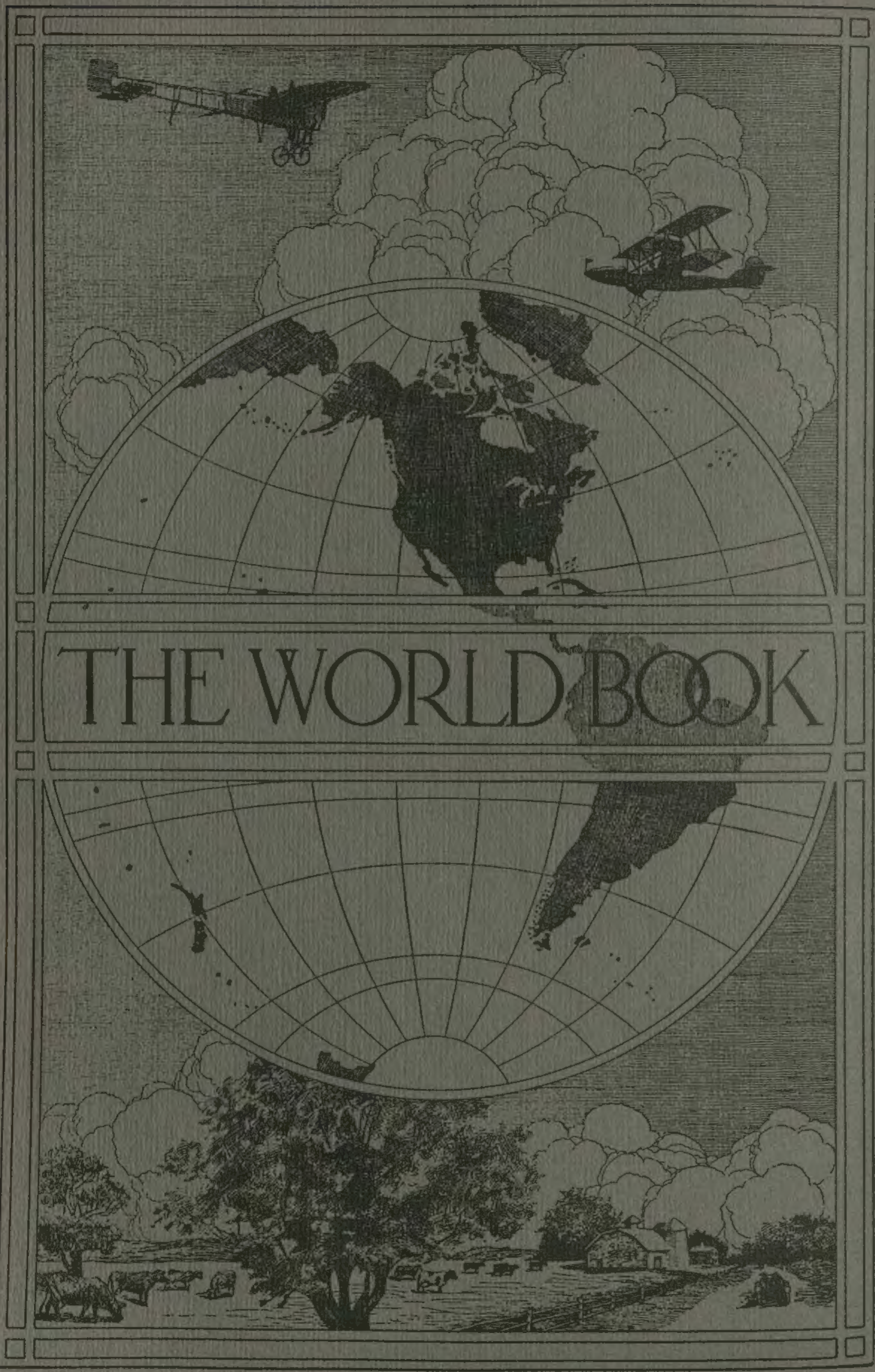
After Japan's defeat in World War II, in 1945, the United States took over the Ryukyus. In 1953, the United States returned the islands north of Okinawa to Japan. Okinawa and the southern Ryukyus were returned in 1972.

Ryzhkov, Nikolai Ivanovich (1929-   ), was premier of the Soviet Union from 1985 to 1990. He resigned in December 1990 after suffering a heart attack. As premier—officially chairman of the Council of Ministers—Ryzhkov was chief administrator of the Soviet government. A specialist in economic planning, Ryzhkov helped oversee efforts to make the Soviet economy more efficient and productive.

Ryzhkov was probably born near Sverdlovsk (now Yekaterinburg). He received an engineering degree from the Urals Polytechnical Institute in 1959. Ryzhkov joined the Communist Party in 1956. He became first deputy minister of heavy machinery in 1975, and was appointed first deputy chairman of Gosplan, the Soviet economic planning commission, in 1979. In 1982, Ryzhkov became a member of the Secretariat of the Communist Party's Central Committee, where he had responsibility for economic affairs. Ryzhkov was a full member of the Communist party's policymaking Politburo from 1985 to 1990.



Nikolai Ryzhkov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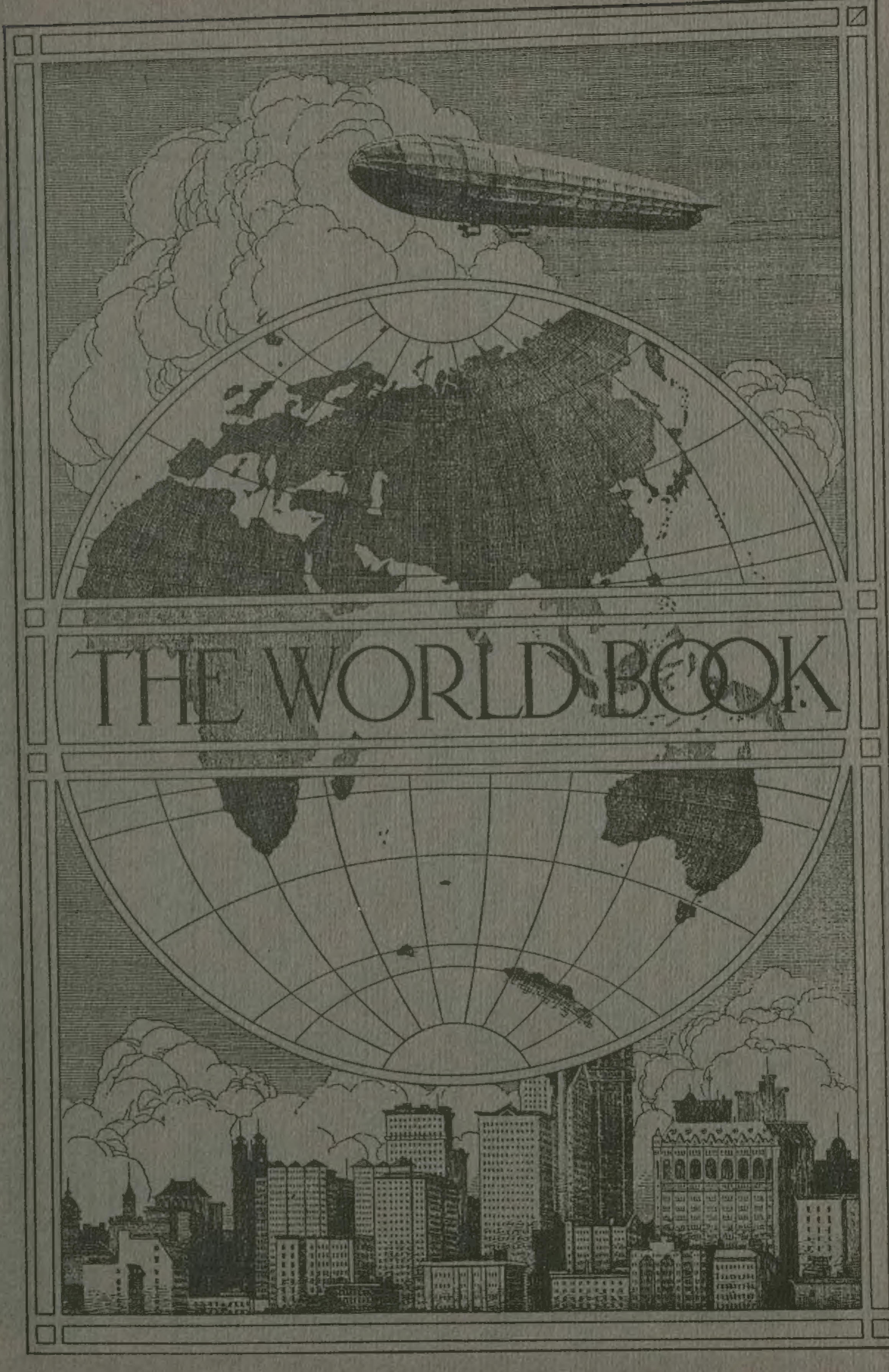
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